FINAL REPORT

WATT-HOUR METER

CONTRACT NO. NAS 5-11524

Prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

By

EMR-AEROSPACE SCIENCES
EMR DIVISION
WESTON INSTRUMENTS, INC.
COLLEGE PARK, MARYLAND

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SECTION 1

CHARACTERISTICS

SECTION 1

CHARACTERISTICS

1.1 INTRODUCTION

The Watt-Hour Meter is a versatile and accurate instrument for measuring watt-hours and ampere-hours over a wide range of voltages and currents. The voltage and current inputs can be widely separated in voltage potential from each other and from earth ground with no degradation in measuring performance. In addition, accuracy is maintained over the frequency range from DC to 100 Hz.

The Watt-Hour Meter uses voltage-to-frequency conversion techniques in order to obtain a pulse rate which is proportional to the watt-hour and ampere-hour inputs. Four solid state counters in the instrument accumulate and store the positive and negative watt-hours and positive and negative ampere-hours. Each can be selected for display on a six-digit Nixie readout. The output of each counter is commutated into a single six-phase BCD output for printout. Relay contact closure outputs are also provided for each of the four outputs permitting the use of external counters. The voltage and current inputs are indicated on front panel meters.

1.2 SPECIFICATIONS

Watt-Hour Meter:

Voltage Ranges:	3, 30, 300 volts full scale. 3, 10, 30, 100, 300 volts full scale on front panel meter.
Current Ranges (External shunt):	100 millivolts shunt full scale. 5a, 50 millivolts with 100% over-ranging. 50a, 50 millivolts shunt with 100% over-ranging.
Readout, Storage, and Print Capacity:	9999.99 watt-hours positive and 9999.99 watt-hours negative (Six complete digits on Nixie readout).
Current Shunt Isolation:	The current shunt input is isolated so that the shunt can be placed at any potential from 5 volts above the positive voltage input to 5 volts below the negative voltage input.
Accuracy:	±1%

Ampere-Hour Meter:

Current Ranges (External shunt):	100 millivolts shunt full scale. 5a, 50 millivolts with 100% over-ranging. 50a, 50 millivolts shunt with 100% over-ranging.
Readout and Storage Capacity:	999.999 ampere-hours positive and 999.999 ampere-hours negative (Six complete digits on Nixie readout).
Accuracy:	±1%

Overall Instrument:

Overload Protection:	Ten times maximum rated inputs will not damage instrument.
Print-Out and Reset Capability:	
Logic and Level to Printer:	1248 Positive Logic, Logic "1" equals 15 volts, Logic "0" equals 0.2 volts.
Print Command:	Front panel or by remote contact closure. All four stored readings are then printed in sequence (on external printer). Bypass provisions are included on front panel which will inhibit printout of any of the four stored readings.
Print Command:	15 volt positive pulse.
Earth Ground Isolation:	All inputs are electrically isolated from earth ground.
Input Impedance:	10 Megohm common mode and 20 Megohm differential on voltage inputs. 1000 ohm on current input.
Frequency:	DC to 100 Hz.
Operating Temperature:	+10°C to +35°C

SECTION 2

OPERATING INSTRUCTIONS

SECTION 2

OPERATING INSTRUCTIONS

2.1 GENERAL

The following instructions explain the use of all front panel controls and all connectors on the instrument. Complete detail for the connectors is contained in Section 6 - Wire List.

2.2 CONTROLS AND CONNECTORS

RANGE SWITCHES - Set the VOLTAGE RANGE and CURRENT RANGE switches to the desired full-range scales.

VOLTAGE INPUT - Connect to either J4 on the rear of the instrument or to J2 on the front panel. Pin A of J4 is positive and pin B is negative input.

CURRENT INPUT - Connect leads from the 50 millivolt shunt to J3 on the rear or J1 on the front panel.

MONITORING COUNT - Rotate the SELECTOR SWITCH to monitor any of the four counters.

PRINTER OUTPUT - A printer may be driven from J5 on the rear. Six digits are provided, plus a code digit. The logic is 1248 BCD, Positive "1". The code digit reads as follows:

3 = Negative ampere-hours

2 = Positive ampere-hours

1 = Negative watt-hours

0 = Positive watt-hours

The four readings are printed out in sequence. However, any of the above readings can be bypassed with the SKIP toggle switches on the front panel.

PRINT COMMAND - The printout sequence of readings to the printer can be initiated by: (1) pushing the PRINT button on the front panel and (2) applying a REMOTE PRINT signal (contact closure between pins E and F of connector J6).

RESET - The four counters can be reset by: (1) pushing the RESET button on the front panel which resets only the counter selected on the SELECTOR SWITCH, (2) the REMOTE RESET signal (contact closure between pins G and H of connector J6) will reset all four counters.

PRINT & RESET - The external contact closure between pins C and D of connector J6 initiates the print sequence to the printer, after which all four counters are reset.

EXTERNAL COUNTERS - A 60 millisecond contact closure is provided for external counters for each of the four channels. The external counter must be capable of receiving three counts per second. The Watt-Hour Counter output pulse rate is always a 0.833 counts per second full scale or 3,000 counts per hour full scale regardless of the scale used. This feature takes advantage of the maximum count rate of the external counter. The Ampere-Hour Counter produces 2.7 counts per second or 10,000 counts per hour on both scales. These contact closure outputs are negative ampere-hours between pins C and D of J7, positive ampere-hours between pins C and D of J8, negative watt-hours between pins C and D of J9, and positive watt-hours between pins C and D of connector J10.

2.3 OPERATOR ADJUSTMENT

If counts are registering in either the (+) Watt Hour counter or (-) Watt Hour counter when no signal is applied, perform the following:

a. Place short across J1 and J2 on the frony panel.
b. Place ampere range switch to 100 amps and voltage range switch to 300 volts.
c. Connect one trace of a dual trace oscilloscope between gray test point board 11 and the floating ground test point. Connect other trace of oscilloscope between blue test board 11 and floating ground test point.
d. Sync scope from the gray test point.

e. Adjust drift adjust pot on front panel for no relative motion between the two traces on the oscilloscope.
f. Disconnect test equipment. Return WHM to normal operation.

SECTION 3

THEORY OF OPERATION

SECTION 3

THEORY OF OPERATION

3.1 INTRODUCTION

The Watt-Hour Meter is basically a voltage-to-frequency conversion device, with a multiplier to provide watt-hours. A Nixie readout provides a convenient display and a control circuit adds the capability of completely remote operation. Referring to the Block Diagram shown in Figure 3-1 and the respective electrical schematics will supplement the following discussions.

3.2 CURRENT BUFFER

The Current Buffer shown on drawing 01-22-503 utilizes a chopper-stabilized operational amplifier to provide a voltage gain of 100. High accuracy is obtained since the chopper-stabilized amplifier exhibits extremely low drift and offset. Full scale input voltage of 100 millivolts produces an output voltage of 10 volts.

3.3 VOLTAGE BUFFER

The Voltage Buffer shown in drawing 01-22-703 features 10 Megohm input inpedance, voltage ranging, 300 percent common mode voltage immunity, and overload protection. These characteristics are obtained by employing a good quality FET operational amplifier in the difference circuit arrangement. Full scale operating voltages are 3 volts output and 3, 30, and 300 volts input. The voltage range switch on the front panel selects the proper feedback resistors.

3.4 CURRENT INTEGRATOR

The Current Integrator shown in drawing 01-22-403 is a continuous integrating device with negligible reset time. The output of the Current Buffer is applied to pin 28 of the Current Integrator card. This voltage is applied directly to the input summing point of integrating amplifier A2 through resistors R1 and R3. The input from the Current Buffer is inverted by operational amplifier A1 and is also applied through resistors R10 and R11 to the input summing point of integrating amplifier A2 when field effect transistor Q1 is "ON". The integrating amplifier is followed by a +10 volt and -10volt threshold detector. The output of each threshold detector is passed through a one-shot circuit. The one-shot outputs are combined and toggle flip-flop (IC9). The flip-flop output controls the state of input field effect transistor Q1 which in turn controls the input polarity of the signal applied to integrating amplifier A2. The integrating sequence

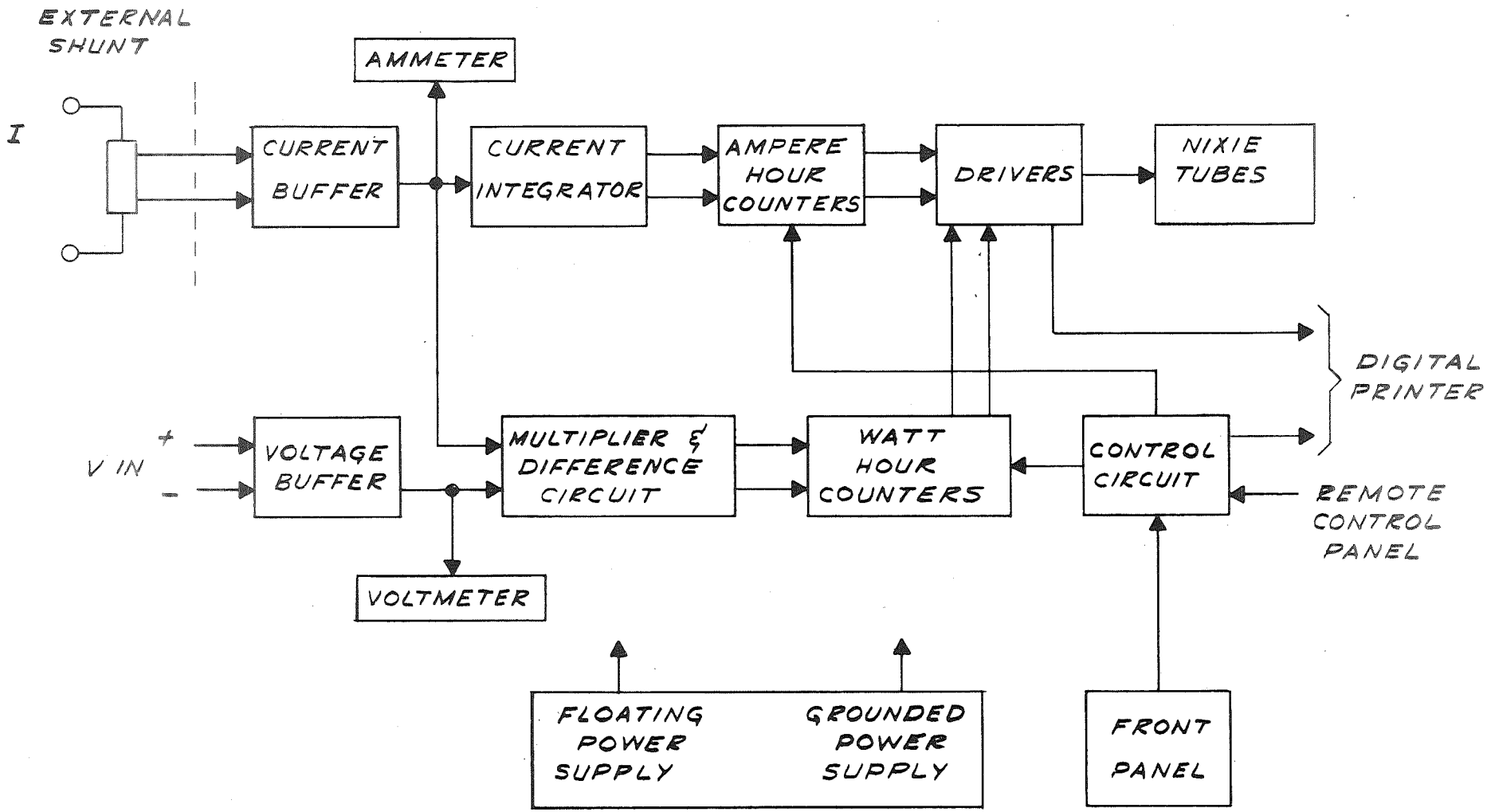


FIG. 3-1 WATT HOUR METER BLOCK DIAGRAM

therefore occurs as follows: Assuming a positive voltage applied to pin 28 and a Q1 "off" initial condition, the input voltage through R1 and R3 will cause the integrating amplifier to produce a negative linear ramp output. When the output of integrating amplifier A2 reaches -10 volts, a pulse will be produced by the -10 volt detector (Amplifier A4) which will toggle flip-flop IC9. The Q output of the IC9 flip-flop will turn "on" the Q1 field effect transistor switch. Since the current through the R10 and R11 resistors is of opposite polarity and is precisely twice the current through resistors R1 and R3, the output of the integrating amplifier will reverse in direction producing a positive linear ramp. The output of the integrating amplifier proceeds positively until +10 volts is reached and the +10 volt threshold detector generates a pulse which toggles flip-flop IC9. The "Q" output of the flip-flop turns "off" Q1 and the above sequence of events repeat. The integrating amplifier's positive and negative time constant is equal providing a continuous integration of the applied current input to the unit. With a negative input, the integrator operates the same as the above description except the Q1 "off" state results in a positive linear ramp being produced by the integrating amplifier. When this output voltage reaches +10 volts, the +10 volt threshold detector will produce a toggle pulse for the IC9 flip-flop. The threshold detector's output and state of the IC9 flip-flop therefore determines if a positive or negative ampere-hour count should be produced.

The count output circuitry, consisting of two flip-flops (IC6) and the six associated gates, serves to eliminate counting errors due to jitter by requiring a "set" count on either output flip-flop before a count is allowed to reach that output terminal.

The unijunction transistor Q5, along with Q4 and Q6, produce a pulse to unlatch the circuit in the event that the pulse from the flip-flop (IC9) does not switch Q1 and, as a result, the output of the integrating amplifier (A2) saturates above 10 volts. Such a latch-up condition must be corrected since it would completely disable the integrator.

The full scale input to the current integrator is 10 volts positive or negative. The full-scale output is 27 counts per second and the polarity of the input determines which output produces the pulses.

3.5 MULTIPLIER AND PULSE SUBTRACTOR

The Multiplier shown on drawing 01-22-603 takes voltages which represent input voltage (E) and input current (I) and produces an output pulse count which is proportional to the product of E and I. The circuit utilizes the relationship $EI = (1/4)\left[(E+I)^2 - (E-I)^2\right]$. Summing amplifier A1 produces (E+I) and difference amplifier A5 produces (E-I). Amplifiers A2 and A6, in conjunction with their 10 volt threshold detectors, produce a

2KHz triangular waveform oscillation when input E and I are zero. A positive or negative input voltage to amplifiers A2 and A6 reduce the voltage; thus, $(E + I)^2$ are generated. The pulse subtractor and a scaling of 1/4 complete the EI formula. Thus, E times I has been generated using circuits which can only add, subtract, and square.

A reversing, constant current source is important to the operation of the squaring circuit. It is generated as follows: the switching circuit Q1, Q2, and Q3 is switched by the latching circuit following the $\pm$ 10 volt detectors at which time it reverses the polarity of the constant current "k" applied to the summing point of amplifier A2. The circuit of Q4, Q5, and Q6 performs the same function for amplifier A6.

The Pulse Subtractor uses 47 pf capacitors to generate a short pulse of only 20 n second. This greatly reduces the possibility of coincidence of the two pulse trains being subtracted. A "set-set-count" output circuit is used to eliminate false counts due to jitter in the 2KHz oscillators.

3.6 WATT-HOUR COUNTERS AND AMPERE-HOUR COUNTERS

The operation of these two types of counters is so similar that only one description of operation is necessary. The counters are shown on drawings 01-22-203 and 01-22-303.

Inhibit circuit - The Counter must remain fixed during the time a reading is being transferred to the printer. If a count is transmitted from the "current integrator" or from the "multiplier" during this transfer interval, it is stored in a RS flip-flop until transfer of the reading to the printer is complete. Then the count is transferred on to the Counter and is counted. Transformer T2 converts the pulse to "earth ground" potential and directs the pulse into the inhibit circuit.

Ranging - After passing through the inhibit circuit, the count pulse is applied to the decade counters. The first stage of the Ampere-Hour Counter or any of the first three stages of the Watt-Hour Counters may be bypassed depending on the setting of the range switches. This properly scales the output.

Read - A "read" command is required to switch "on" all BCD output control gates before they can be sent to the Nixies or to the printer.

Count output for remote counter - The count output pulse train from each of the four decade Counters is provided to drive an external counter. A one-shot and a reed relay provide a 60 millisecond contact closure for driving the external counter.

3.7 DRIVER CARD

The Six Driver Cards, shown on drawing 01-22-103, receive binary-coded decimal readings from whichever counter is commanded to "read". The Nixie driver (SN7441N) drives the Nixie tube and the transistor drivers apply the 1248 BCD input to the printer.

3.8 CONTROL CIRCUIT

The Control Circuit, shown on drawing 01-22-503, receives commands from the front panel and from remote inputs. In turn, it generates and coordinates the commands which control the operation of the Watt-Hour Meter and the external printer.

When the PRINT button is pushed or a Remote Print Command signal is received, the Print RS Flip-Flop is switched to its "set" state. The "set" output pulse resets the Count to Four Counter (SN7473N) sending a "read" command to the Minus Ampere-Hour Counter Card. The "set" pulse also turns on the Astable Oscillator (Q4) which sends out a "print command" pulse and the first reading is printed. The Astable Oscillator pauses and then, simultaneously, steps the "Count to Four Counter" and sends out a "print command" pulse about every one-half second until the "Count to Four Counter" reaches zero (sequence is 0, 1, 2, 3, 0) at which time the "Count to Four Counter" resets the Print RS Flip-Flop.

If any of the SKIP toggle switches are on, the Count to Four Counter ripples ahead until it reaches a number where that toggle switch is not switched on.

When the RESET button is pushed, a DC reset signal is transmitted to the Counter selected by the SELECTOR switch.

When the Remote Reset signal is received, all four Counters are directly reset to zero.

When a Remote Print and Reset command is received, the print cycle is the same as when the PRINT button is pushed. In addition, the RESET flip-flop is set which causes all four counters to be reset after the print cycle is complete.

Transistor Q3 is part of a one-shot which produces a reset pulse width of 100 milliseconds. This pulse width is required to prevent the counter boards from transmitting a false count to the external counters at the time any of the four Counters are reset.

Transistors Q1 and Q2 establish the Print Flip-Flop and the Reset Flip-Flop in their reset mode when power is applied to the circuit. Otherwise, unwanted print command and reset pulses would be sent out by the Control Circuit.

SECTION 4

ALIGNMENT PROCEDURES

SECTION 4

ALIGNMENT PROCEDURES

4.1 EQUIPMENT REQUIRED

This section describes the alignment procedure for the Watt-Hour Meter. The following equipment is required to perform this alignment.

a. Digital Voltmeter having at least 4 place readout and 0.01% accuracy.

b. Frequency counter with 10 second period counting capability.

c. Oscilloscope - dual trace.

d. Precision voltage supply with 0.01% accuracy - voltage range from 1.0 millivolts to 0.1 volts.

e. Precision voltage supply with 0.01% accuracy - voltage range from 0.3 volts to 300.0 volts.

f. Stopwatch.

g. Audio sine wave generator.

h. RMS meter.

i. Two resistance decade boxes.

4.2 CURRENT BUFFER

a. Place a jumper across J1 on the front panel. Connect DVM between Red test point and black test point on Board 13 and adjust potentiometer R3 until DVM reads 0.000 ± .002 volts.

b. Connect precision voltage supply to J1 and adjust supply to +100.0 ± .1 millivolts. Adjust R4 so that the DVM reads -10.00 volts ± .01 volts.

4.3 VOLTAGE BUFFER

a. Place a jumper across J2 on the front panel. Connect DVM between Red test point and Black test point on board

14 and adjust potentiometer R10 until DVM reads 0.000 ± .002 volts with the voltage range switch in the 3V position.

b. Remove the jumper and apply +3.000 ± .001 volts to J2. The DVM should read -3.000 ± .003 volts. Change voltage range switch to 30 volt position and apply +30.000 ± .001 volts to J2. The DVM should read -3.000 ± .003 volts. Change the voltage range switch to 300 volt position and apply +300.00 ± .03 volts to J2. The DVM should read -1.000 ± .003 volts. If the preceding readings are not withing tolerance, the following procedure 5.3 (c) must be followed.

c. If the full scale output measured in (b) is out of tolerance, connect a sine wave generator between (+) input of J2 and Black test point on board 14 (Reference drawing 01-22-703). Set frequency to 100 cps and RMS voltage to 2 volts. Attach RMS meter in parallel with DVM between Red test point and black test point board 14. Remove the two resistors which are in series with the out-of-tolerance switch position i.e., remove R39 and R36 if the full scale output in the 3V position was out of tolerance. Attach Decade Boxes in place of the resistors removed. Adjust resistor values so that the output is within 0.1 per cent of the correct value and the RMS meter value is minimum. The ratio of resistance between the two feedback legs directly effects the common-mode rejection of the amplifier; therefore, the legs must be balanced for minimum RMS signal at the amplifier output. Replace the TBD resistors with resistors having the value determined by the decade resistor boxes.

4.4 CURRENT INTEGRATOR

The Current Buffer must be adjusted before these adjustments can be made.

Drift Adjustments

a. Apply about 1.0 mv to J1 on front panel. Connect a DVM and oscilloscope between the red test point on board 12 and the floating ground test point. If the voltage at this point is going in the negative direction as observed on the oscilloscope, place a jumper across J1 and adjust trimpot R13 so that the voltage reading on the DVM does not change. If the voltage is going in the positive direction, wait until it reaches +10 volts at which time it will change direction and the above procedure can be performed.

b. Again apply +1.0 mv to J1 on front panel and observe the oscilloscope. If the voltage at the red test point board 12 is going in the positive direction, place a jumper across J1 and adjust trimpot R5 so that the voltage reading on the DVM does not change.

NOTE: There is some interaction between R5 and R13 so go through steps (a) and (b) above several times or until there is no drift in either state of the current integrator.

± 10 Volt Threshold Detector Adjustments

c. Place a 100 KΩ resistor between the red test point and green test point on board 12. Connect a DVM between the red test point board 12 and the black test point board 13. Connect an oscilloscope between the blue test point board 12 and the floating ground test point. Increase the voltage applied to J1 on the front panel to about +100 mv (until the DVM reads +10.00 volts). (NOTE: If DVM reads near -10 volts instead of +10 volts increase the voltage applied to J1 momentarily to clock IC9 and invert the input voltage to A2). Adjust R15 until the oscilloscope indicates that A3 is on the threshold of switching (between 4 volts and zero volts). Decrease the voltage applied to J1 and then increase it again to check that A3 does switch when the DVM reaches +10.00 volts.

d. Repeat step (c) with a negative voltage applied to J1 and -10.00 volts on the DVM. Adjust trimpot R18 so that the -10 v detector A4 switches (indicated by the oscilloscope at the gray test point) at -10.00 volts on the DVM.

e. Remove the 100 KΩ resistor connected between red and green test point.

Frequency Adjustment

f. Apply +100 mv ±0.1 mv to J1 on the front pan l. Connect counter with 10 meg input impedance or higher between orange test point board 12 and the floating ground test point. If counter does not have high enough input impedance connect oscilloscope to orange test point and drive counter from trigger or gate output of scope. Adjust R1 to give a 10 or 100 period average of 36.00 ±.005 m sec. (This corresponds to an output pulse rate of 27.77 counts per second.)

4.5 MULTIPLIER

a. Place jumpers across the J1 and J2 input connectors located on the front panel.

b. Set Drift Adjust pot. on front panel to approximately mid position.

c. Connect counter and oscilloscope between the blue test point on board 11 and the floating ground test point. Adjust R12 to obtain a frequency output of 2000 ± 1 Hz. Adjust R14 until the signal observed on the oscilloscope is an exactly symmetrical square wave. Readjust R12 until the frequency output is 2000 ± .2 Hz.

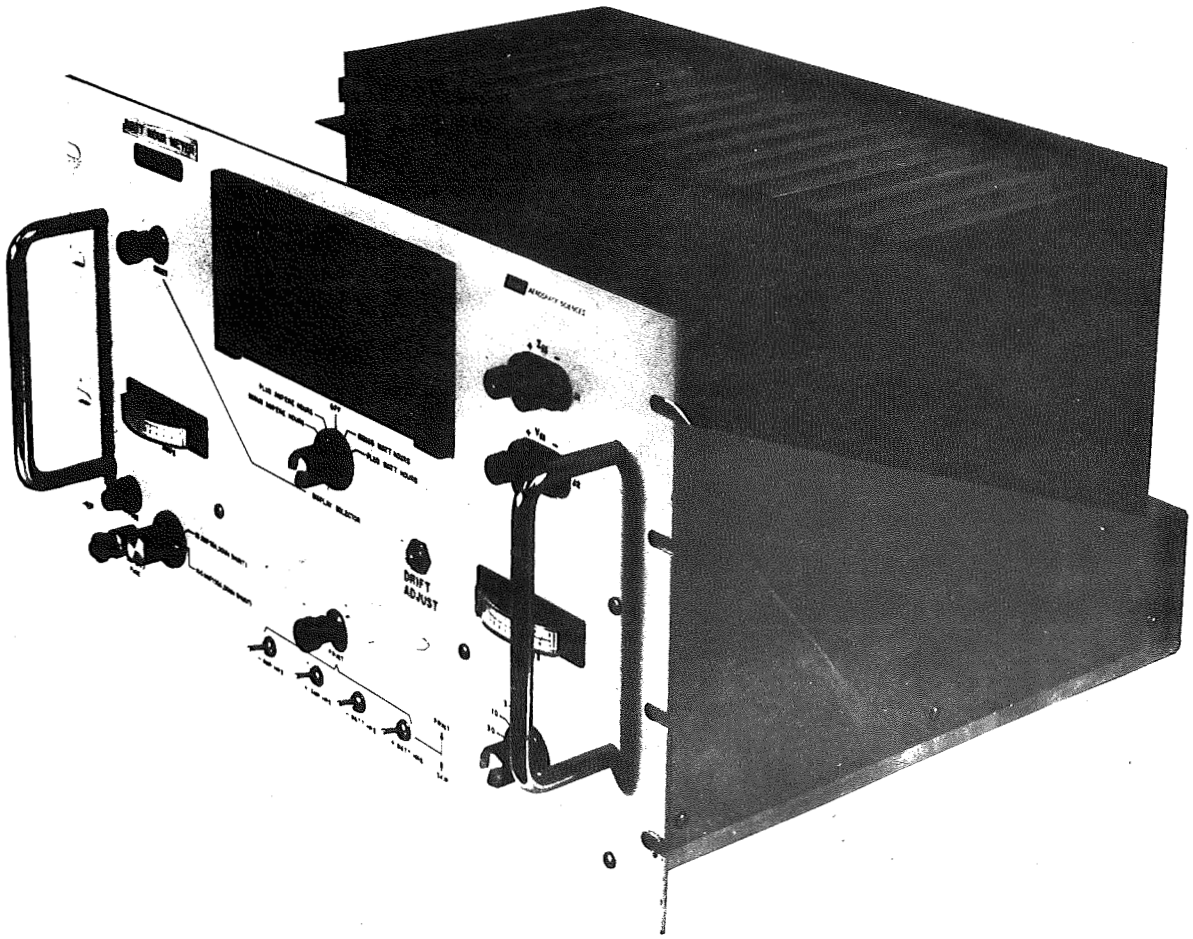
d. Connect counter and oscilloscope between the gray test point on board 11 and the floating ground test point. Adjust R35 to obtain a frequency output of 2000 ± 1 Hz. Adjust R37 until the signal observed on the oscilloscope is an exactly symmetrical square wave. Readjust R35 until the frequency output is 2000 ± .2 Hz.

e. Remove jumpers from across J1 and J2 and apply +3.000 ± .001 volts to J2 and +100.0 ± .1 millivolts to J1. Set the voltage range switch to 3 volts. Adjust the frequency at the blue test point to 1,167 Hz using potentiometer R7 on board P11. Reverse polarity of signals to J1 and J2 and observe frequency at the blue test point. If the frequency is not 1,167 ± 1 Hz, R15 should be adjusted until the frequency with both polarities are equal. During this procedure, R7 may require readjustment to retain the 1,167 Hz frequency.

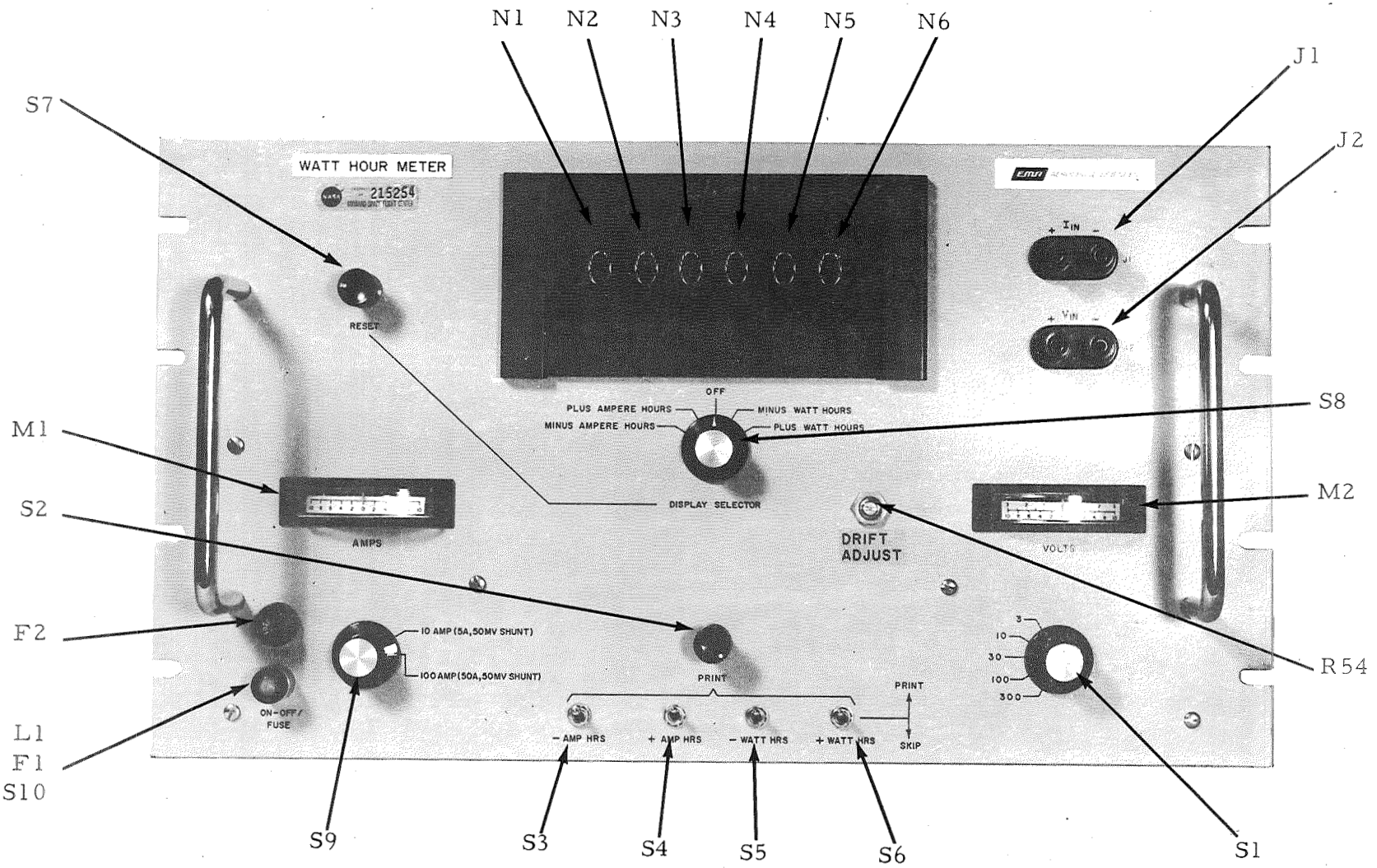
f. The same procedure as (e) is used to adjust the frequency at the gray test point with the exception that the voltage must be of opposite polarity as the current input. R33 is used to set the 1,167 Hz frequency and R38 is used to set the balance.

SECTION 5

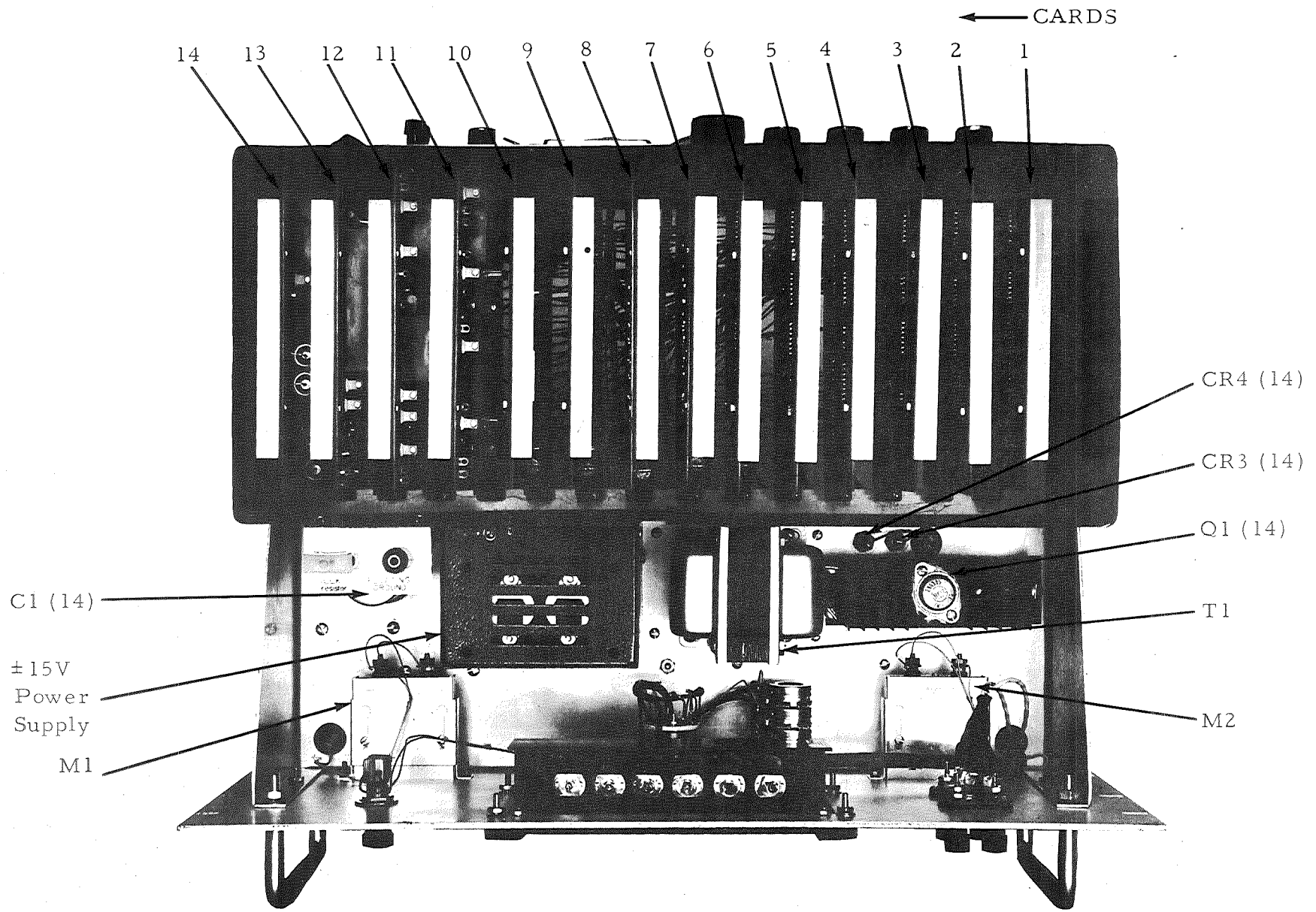
EQUIPMENT PHOTOGRAPHS



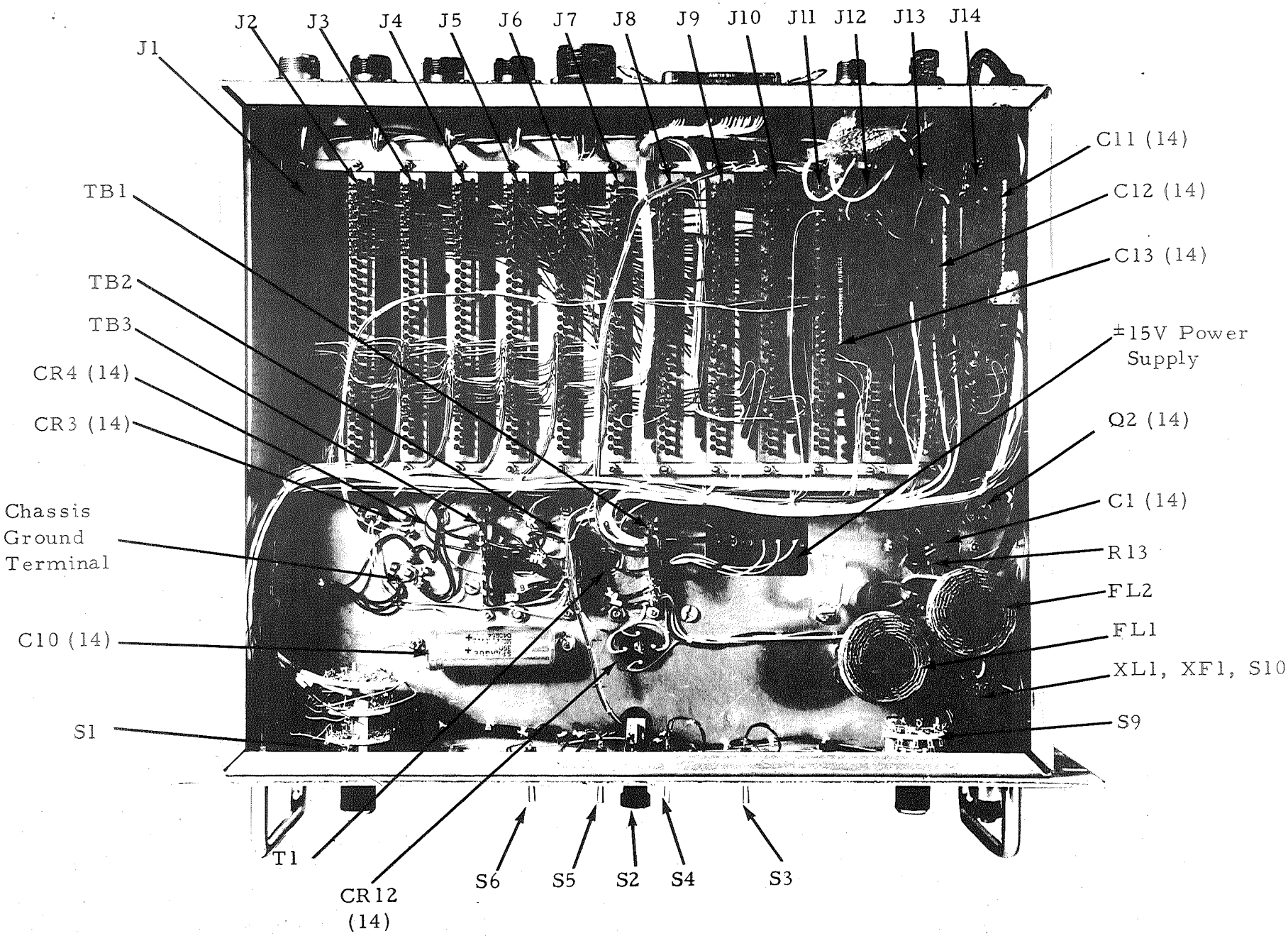
RIGHT OBLIQUE


N1
N2
N3
N4
N5
N6
J1
J2
S7
S8
M1
S2
M2
R54
F2
L1
F1
S10
S9
S3
S4
S5
S6
S1
WATT HOUR METER
215254
RESET
OFF
PLUS AMPERE HOURS
MINUS WATT HOURS
MINUS AMPERE HOURS
PLUS WATT HOURS
DISPLAY SELECTOR
AMPS
DRIFT ADJUST
VOLTS
10 AMP (5A, 50MV SHUNT)
100 AMP (50A, 50MV SHUNT)
PRINT
ON-OFF / FUSE
- AMP HRS
+ AMP HRS
- WATT HRS
+ WATT HRS
PRINT
SKIP
3
10
30
100
300

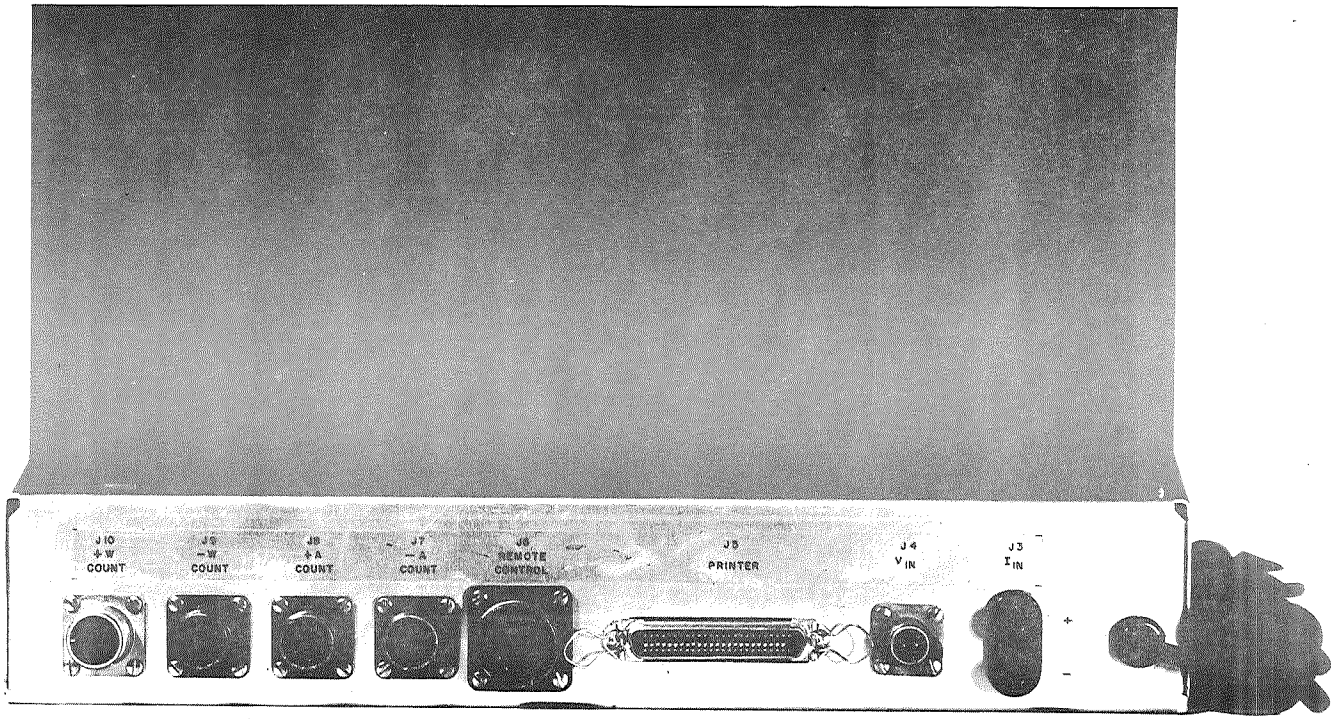
FRONT VIEW


CARDS
14
13
12
11
10
9
8
7
6
5
4
3
2
1
CR4 (14)
CR3 (14)
Q1 (14)
C1 (14)
T1
±15V
Power
Supply
M1
M2

TOP VIEW


J1
J2
J3
J4
J5
J6
J7
J8
J9
J10
J11
J12
J13
J14
TB1
TB2
TB3
CR4 (14)
CR3 (14)
Chassis Ground Terminal
C10 (14)
S1
T1
CR12 (14)
S6
S5
S2
S4
S3
C11 (14)
C12 (14)
C13 (14)
±15V Power Supply
Q2 (14)
C1 (14)
R13
FL2
FL1
XL1, XF1, S10
S9

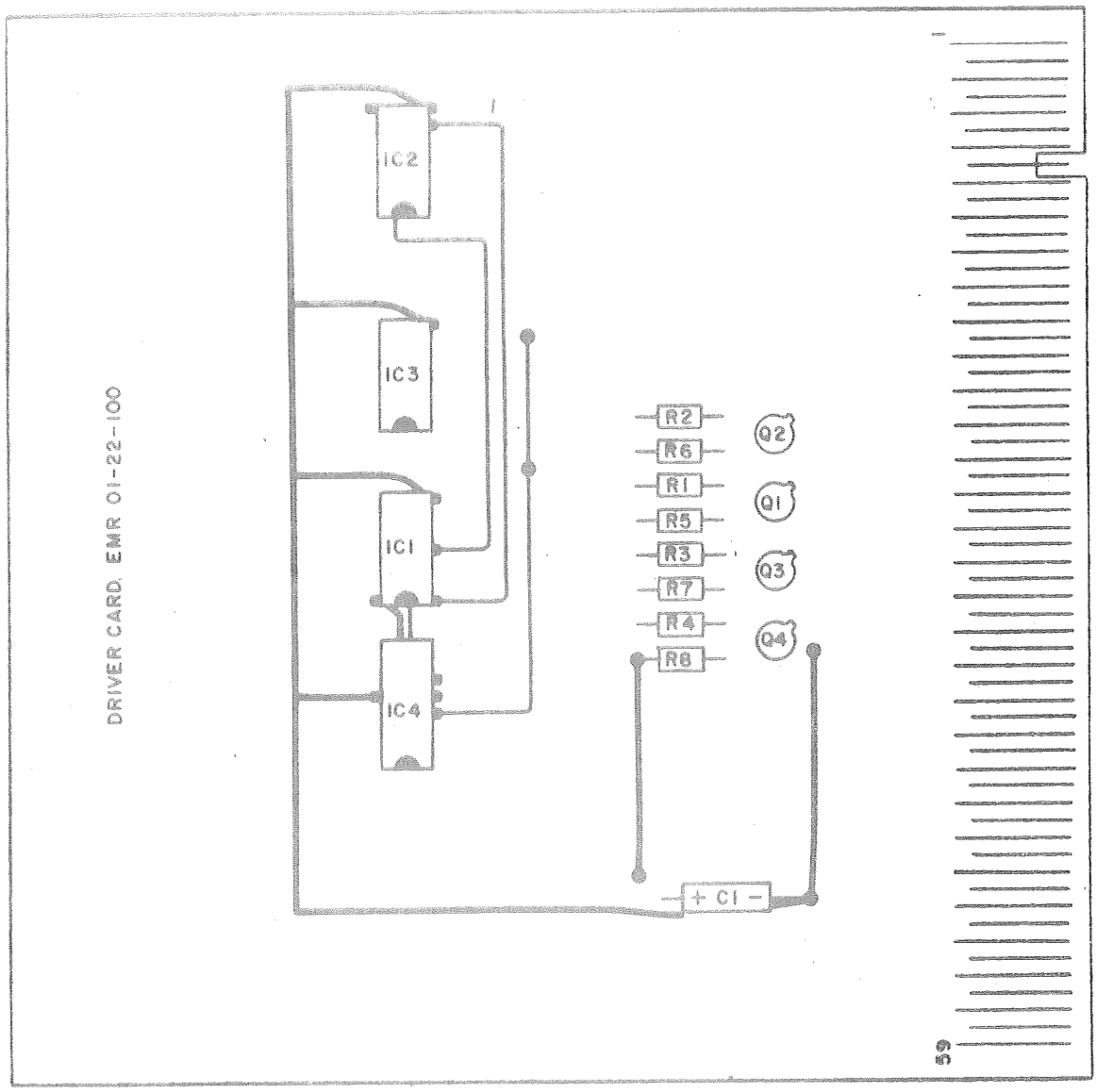
BOTTOM VIEW


J10
+W
COUNT
J9
−W
COUNT
J8
+A
COUNT
J7
−A
COUNT
J6
REMOTE
CONTROL
J5
PRINTER
J4
V IN
J3
I IN
−
+
−

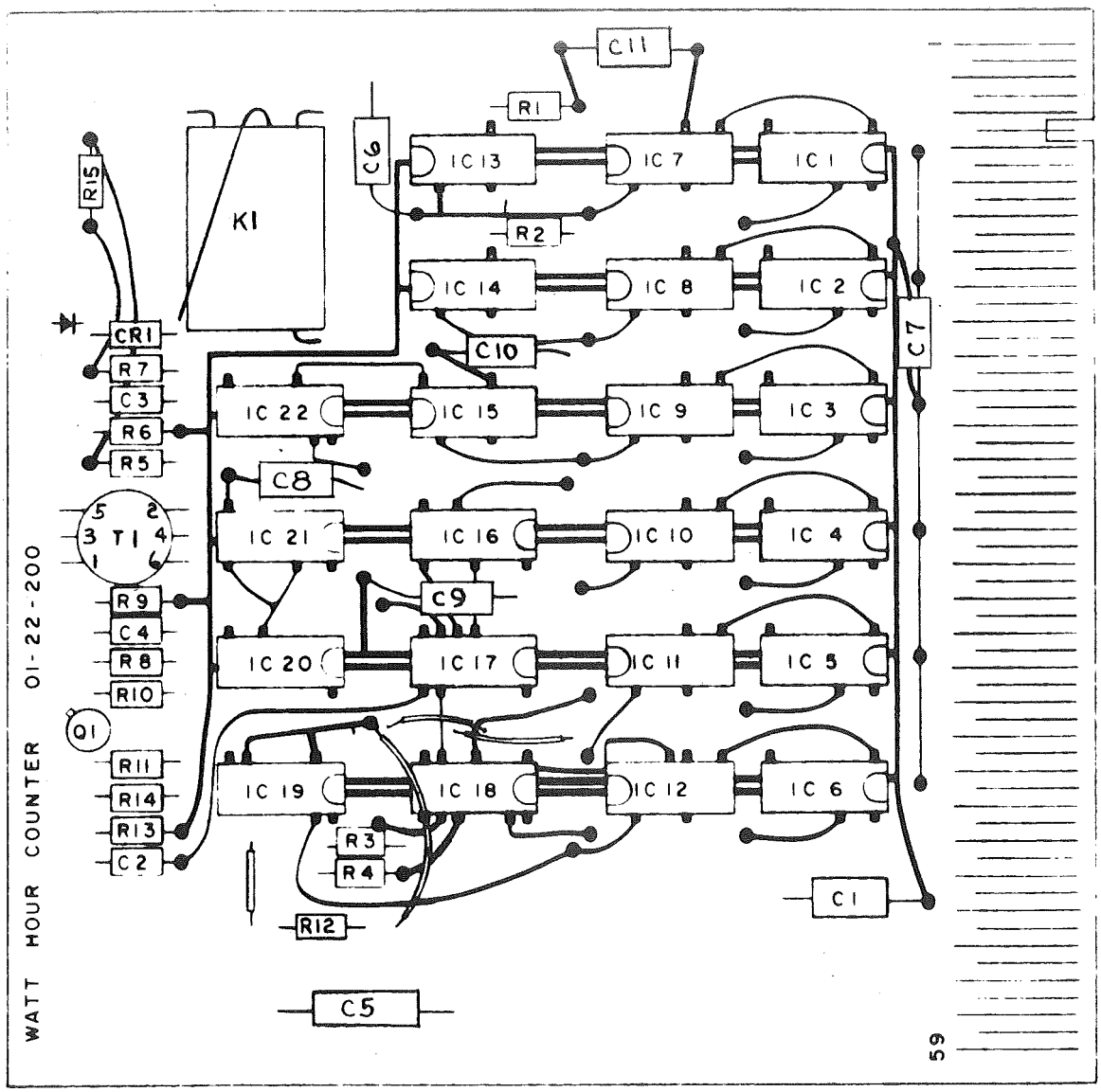
REAR VIEW

SECTION 6

PRINTED CIRCUIT CARDS

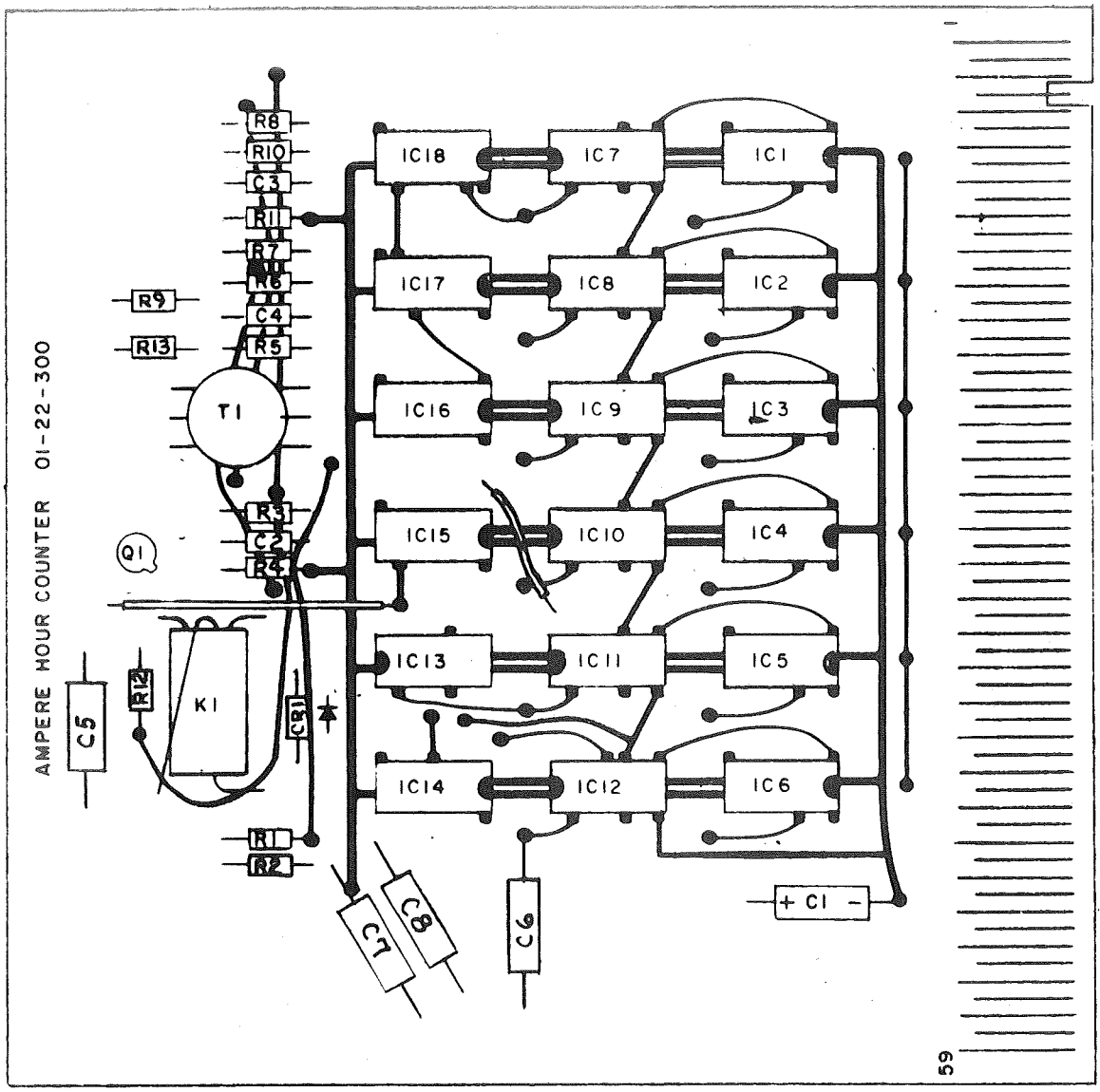


DRIVER CARD ASSEMBLY
(REF) DWG. NO. 01-22-100



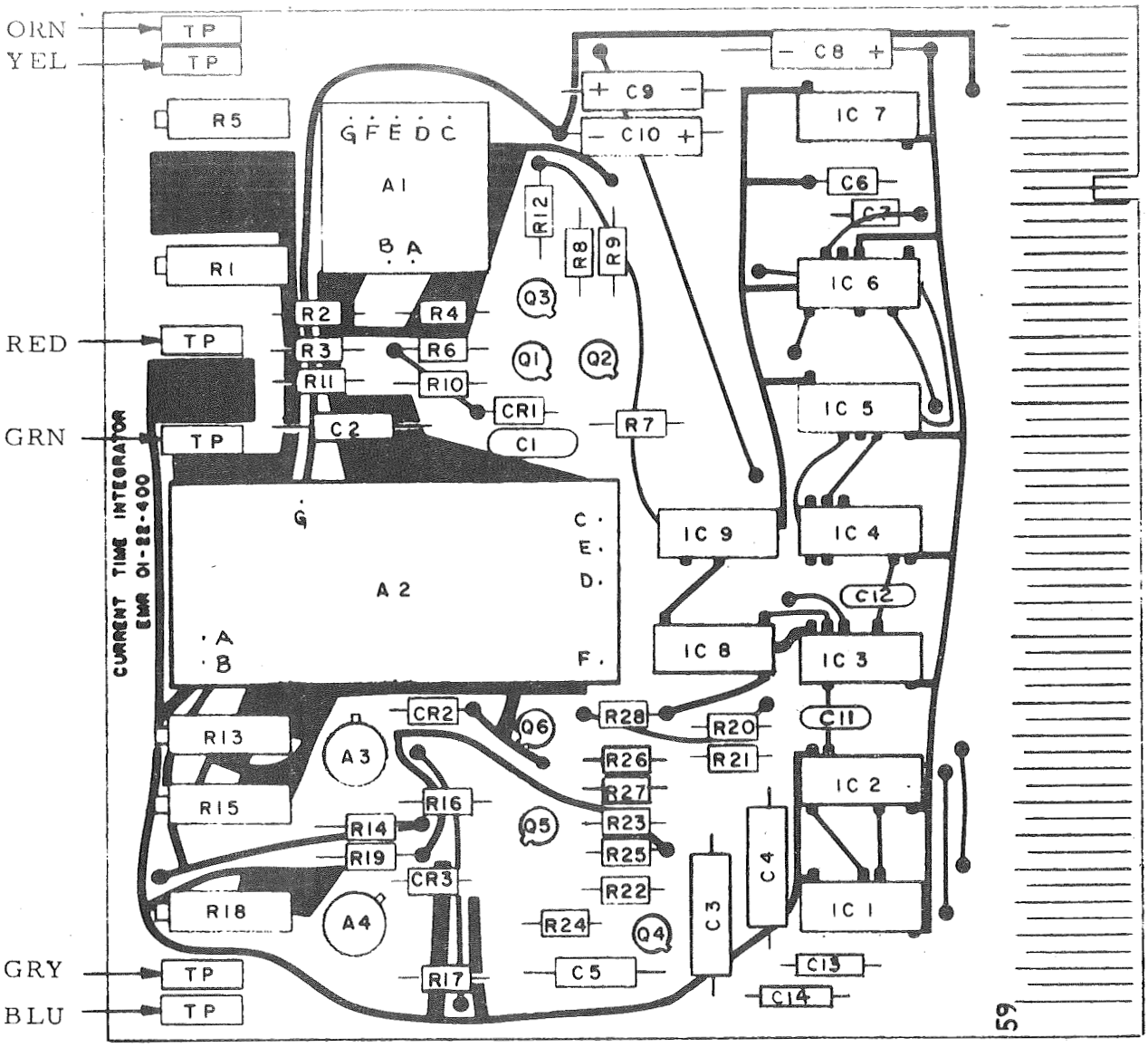
NOTE: Jumper wires between Pins 7 and 10 on IC's 7, 8, 9, 10, 11, 12, 13, 14, and 15 not shown, located on far side of board.

WATT HOUR COUNTER ASSEMBLY
(REF) DWG. NO. 01-22-200



NOTE: Jumper wires between Pins 7 and 10 on IC's 7, 8, 9, 10, 11, 12, and 13 not shown, located on far side of board.

AMPERE HOUR COUNTER ASSEMBLY
(REF) DWG. NO. 01-22-300



NOTE: Jumper wires located on Sheet 2

CURRENT TIME INTEGRATOR ASSEMBLY
(REF) DWG. NO. 01-22-400
(SHEET 1 of 2)

NOTE: The following Jumper Wires were not shown.

1. Jumper Wire, From: Connector Pin 6
   To: Orange Test Point

2. Jumper Wire, From: C13
   To: R19

3. Jumper Wire, From: C14
   To: R15

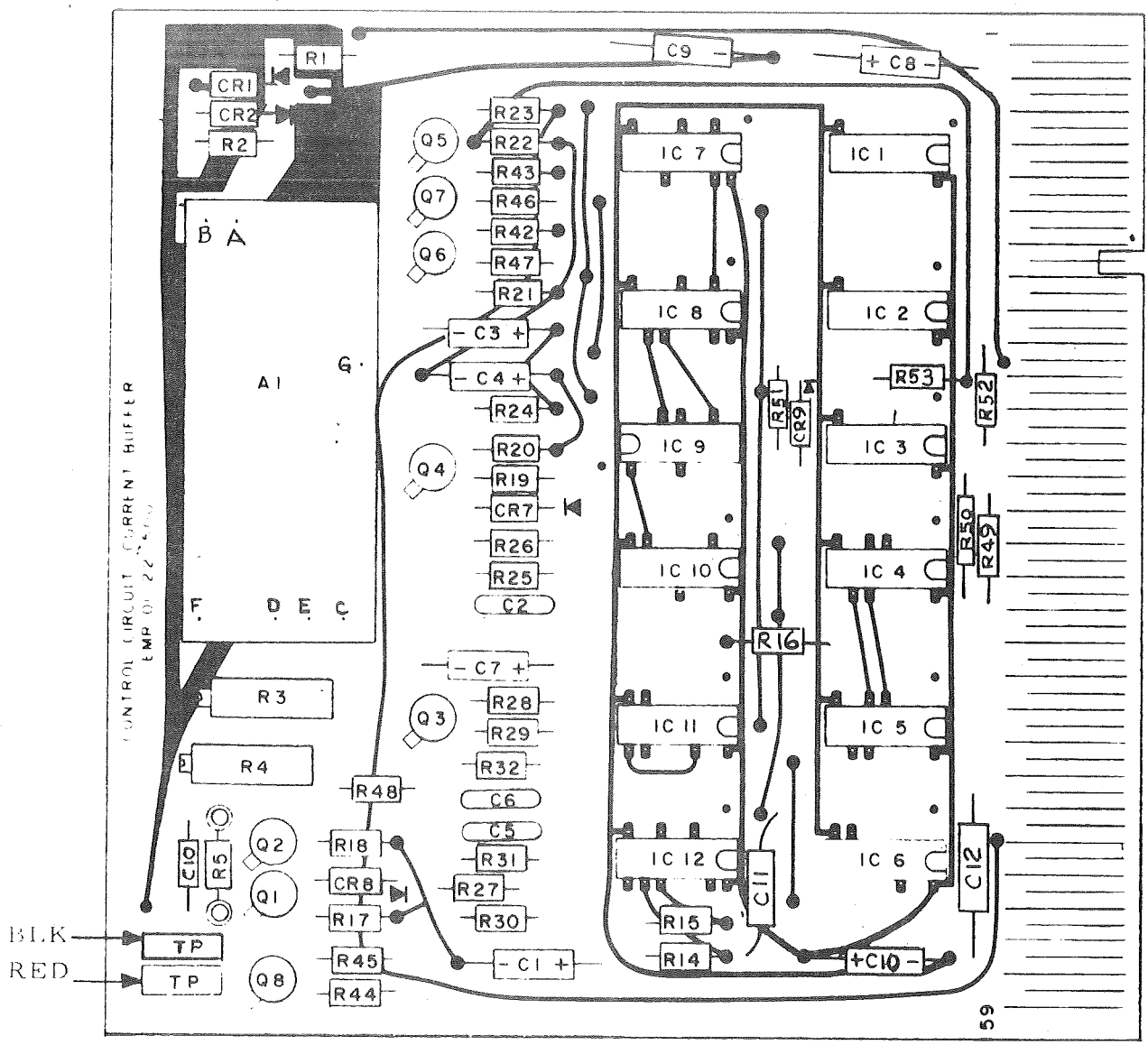
4. Jumper Wire, From: A1 Pin D
   To: Connector Pin 9

5. Jumper Wire, From: Connector Pin 7
   To: Junction of C9 and C10

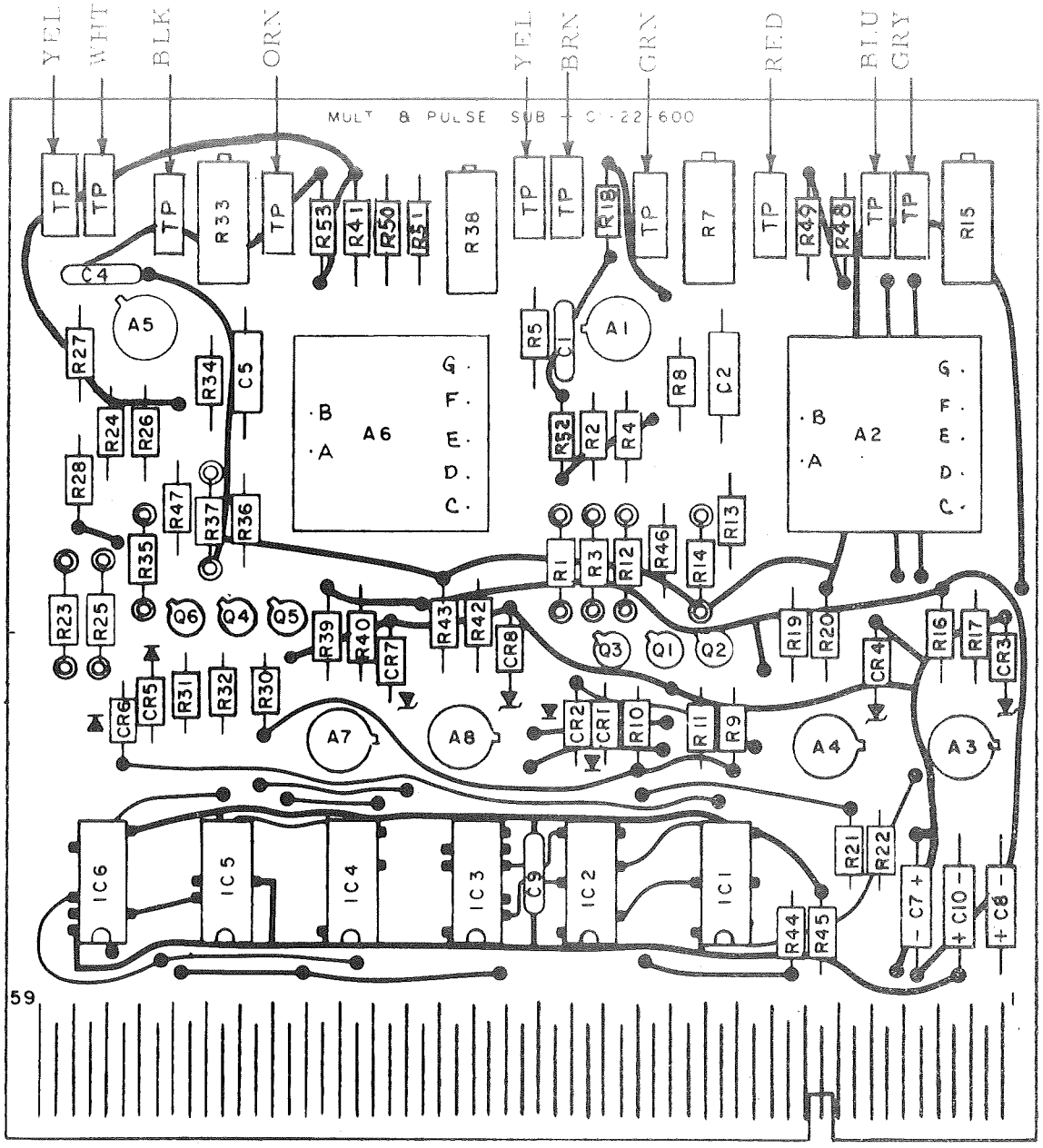
6. Jumper Wire, From: Connector Pin 7
   To: A2 Pin D

7. Jumper Wire, From: Connector Pin 8
   To: A2 Pin B

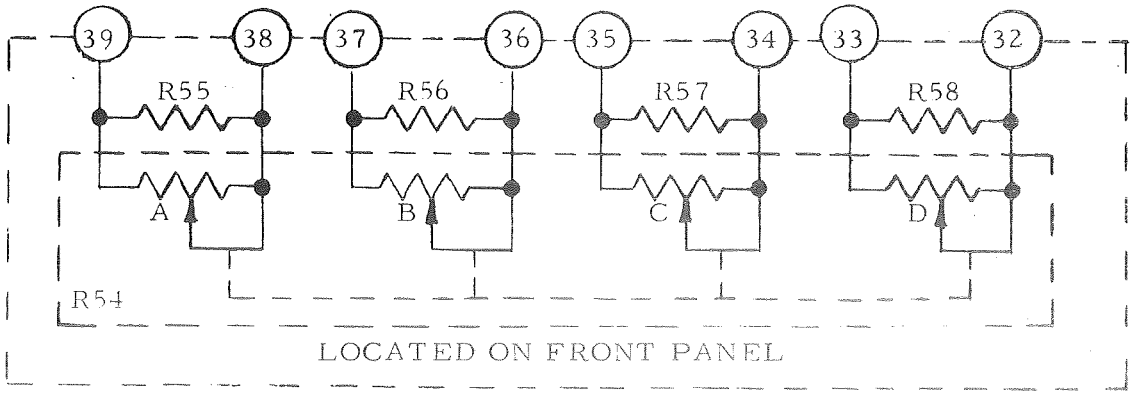
8. Jumper Wire, From: Connector Pin 8
   To: A1 Pin B



CONTROL CIRCUIT - CURRENT BUFFER ASSEMBLY
(REF) DWG. NO. 01-22-500



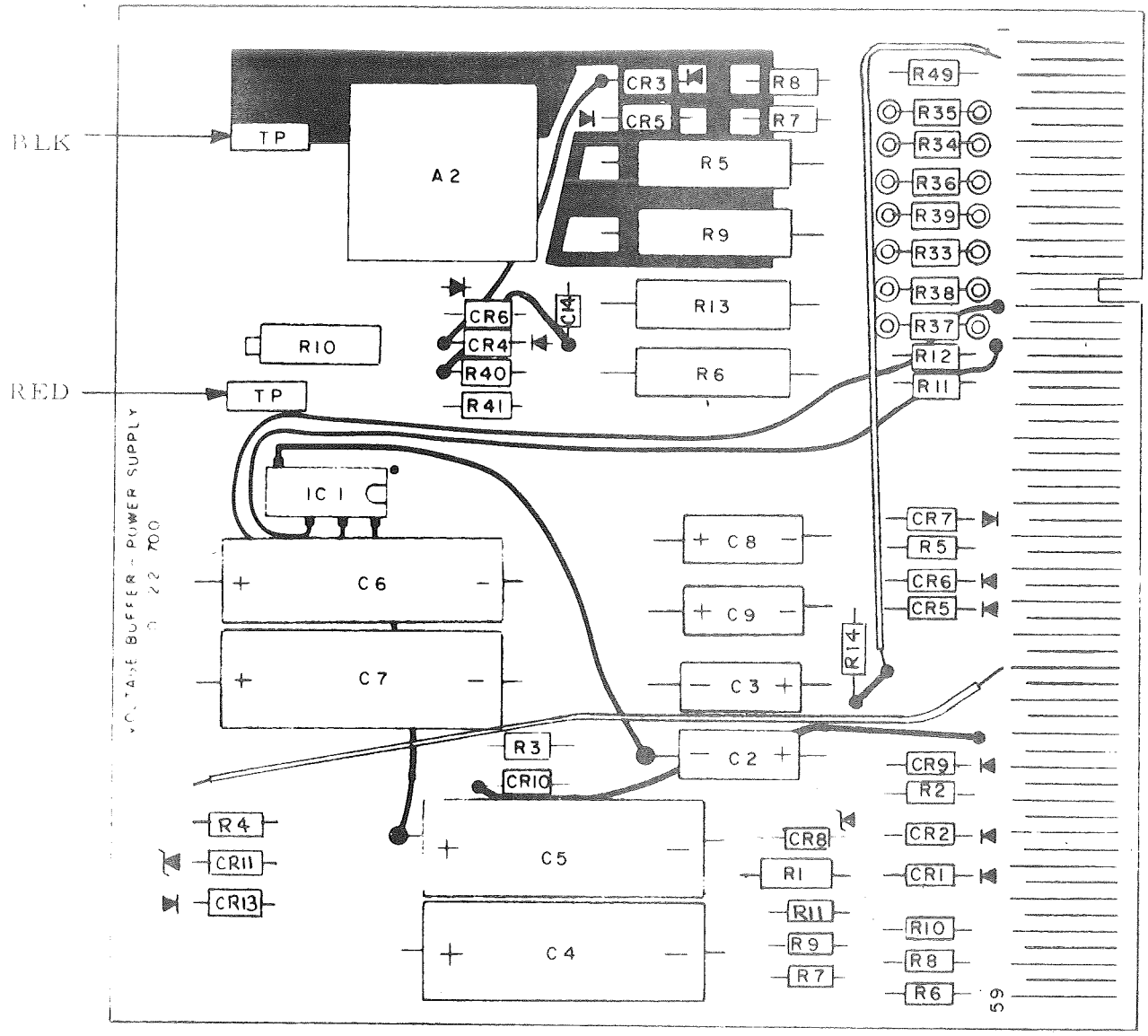
JUMPER WIRES LOCATED ON SHEET 2



MULTIPLIER AND PULSE SUBTRACTOR ASSEMBLY
(REF) DWG. NO. 01-22-600
(SHEET 1 of 2)

NOTE: The following Jumper Wires were not shown.

1. Jumper Wire, From: A1 Pin 3
   To: Connector Pin 10
2. Jumper Wire, From: R28
   To: Connector Pin 9
3. Jumper Wire, From: A2 Pin B
   To: Connector Pin 8
4. Jumper Wire, From: A6 Pin B
   To: Connector Pin 8
5. Jumper Wire, From: Connector Pin 32
   To: R13
6. Jumper Wire, From: Connector Pin 33
   To: R14
7. Jumper Wire, From: Connector Pin 34
   To: R46
8. Jumper Wire, From: Connector Pin 35
   To: R12
9. Jumper Wire, From: Connector Pin 36
   To: R36
10. Jumper Wire, From: Connector Pin 37
    To: R37
11. Jumper Wire, From: Connector Pin 38
    To: R47
12. Jumper Wire, From: Connector Pin 39
    To: R35

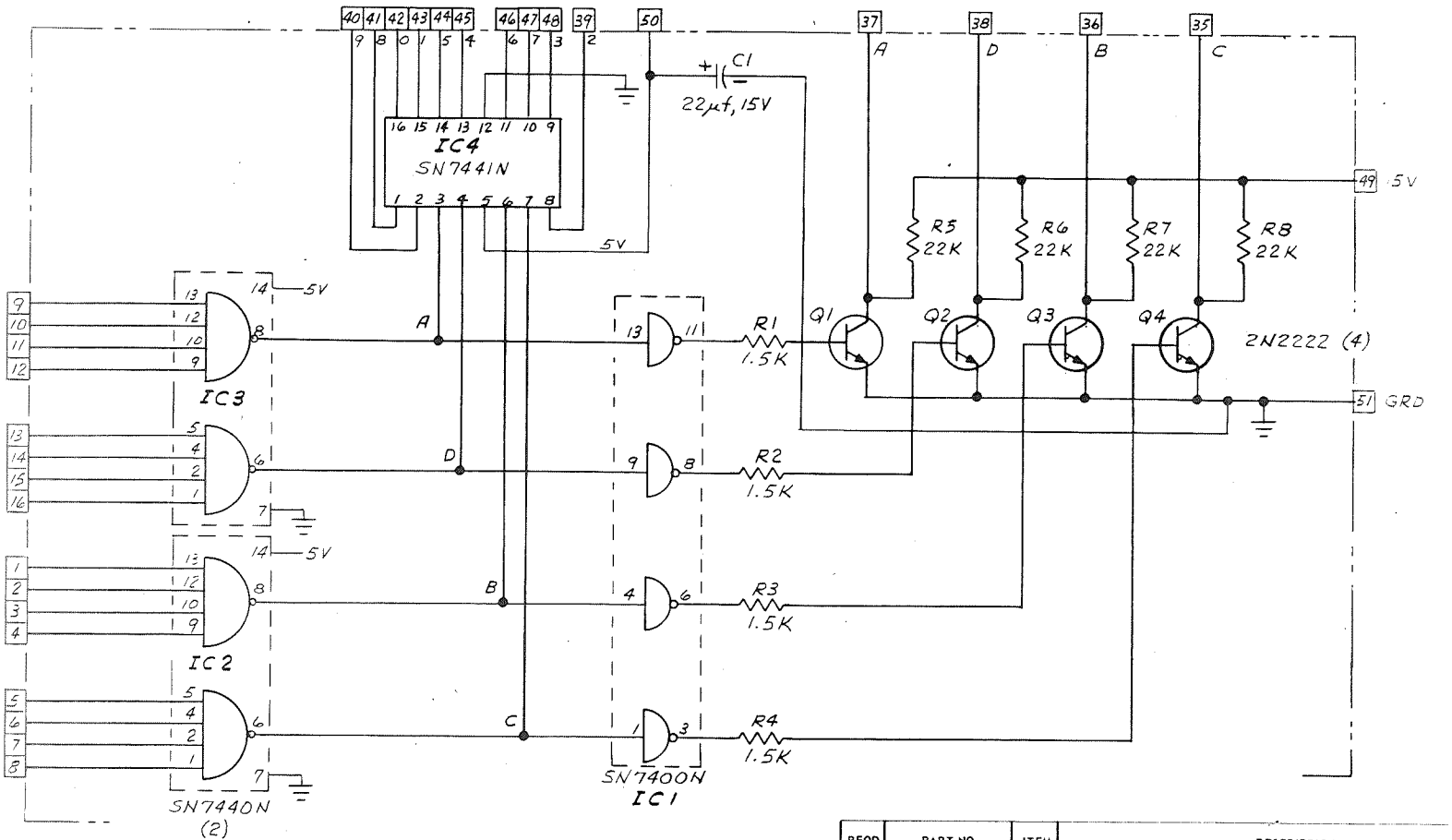


VOLTAGE BUFFER - POWER SUPPLY ASSEMBLY
(REF) DWG. NO. 01-22-700

SECTION 7

SCHEMATICS

SYM	DESCRIPTION	DATE	APPROVED



01-22-103

REQD	PART NO.	ITEM	DESCRIPTION	SYM

LIST OF MATERIALS

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON FRACTIONS DECIMALS ANGLES
MATERIAL
TREATMENT OR FINISH

	DRAWN BY	DATE
	Al Elliott	7-22-65
CHECKED	W R Work	4-7-70
ENGINEER	M Sampson	7-12-67
APPROVED		11-17-70
APPROVED		

NEXT ASSY | USED ON

EMR-AEROSPACE SCIENCES DIVISION
ELECTRO-MECHANICAL RESEARCH, INC.
COLLEGE PARK, MARYLAND

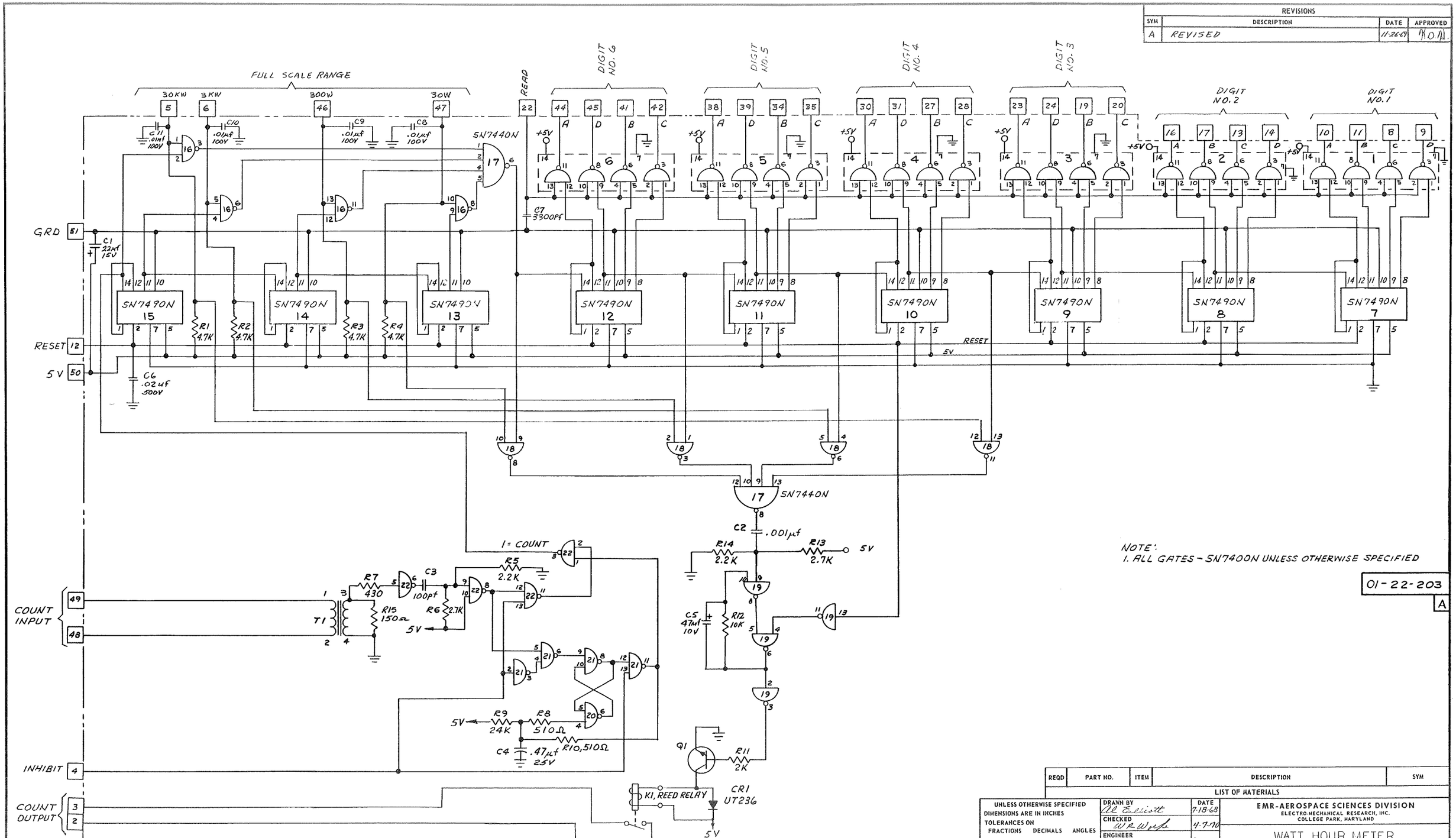
WATT HOUR METER

DRIVER CARDS P1 THRU P6
LOGIC DIAGRAM

CODE IDENT NO.	SIZE	
06141	C	01-22-103

SCALE ~ | SHEET

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED
A	REVISED	11-26-69	[illegible]



NOTE:
1. ALL GATES - SN7400N UNLESS OTHERWISE SPECIFIED

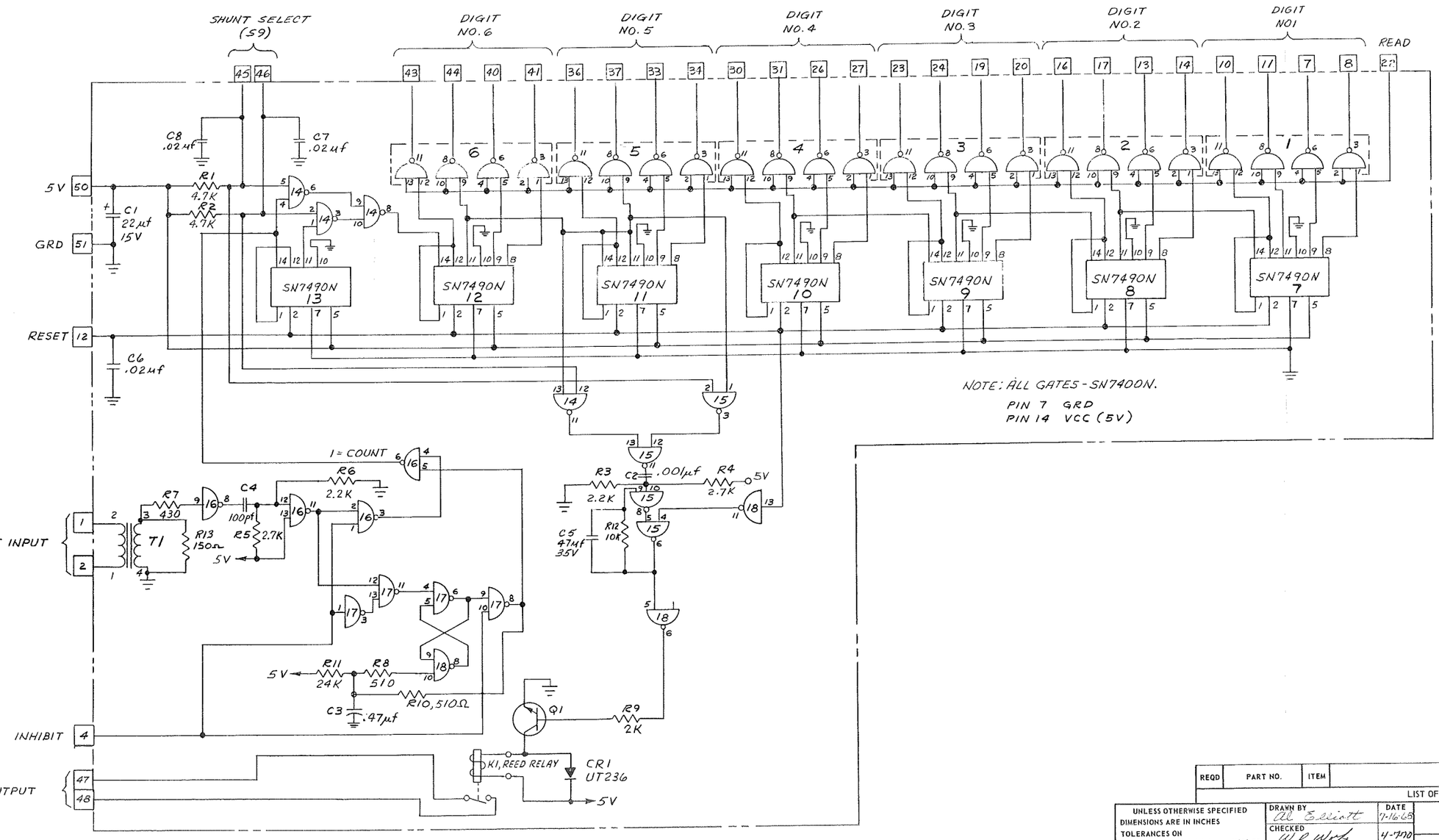
01-22-203
A

REQD	PART NO.	ITEM	DESCRIPTION	SYM

LIST OF MATERIALS

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS DECIMALS ANGLES	DRAWN BY Al Escott	DATE 7-18-68	EMR-AEROSPACE SCIENCES DIVISION ELECTRO-MECHANICAL RESEARCH, INC. COLLEGE PARK, MARYLAND
	CHECKED W R Wolfe	4-7-70	WATT HOUR METER
	ENGINEER M Lawson	7-12-68	WATT HOUR COUNTER CARDS P7 & P8
MATERIAL	APPROVED [illegible]	11-12-70	LOGIC DIAGRAM
TREATMENT OR FINISH	APPROVED		CODE IDENT NO. 06141 / SIZE D / 01-22-203 A
NEXT ASSY 6341-9038 USED ON			SCALE ~ / SHEET

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED
A	REVISED & REDRAWN	11-25-69	[illegible]



NOTE: ALL GATES - SN7400N.

PIN 7 GRD
PIN 14 VCC (5V)

01-22-303
A

REQD	PART NO.	ITEM	DESCRIPTION	SYM

LIST OF MATERIALS

NEXT ASSY	6341-9038
USED ON	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON FRACTIONS DECIMALS ANGLES

MATERIAL

TREATMENT OR FINISH

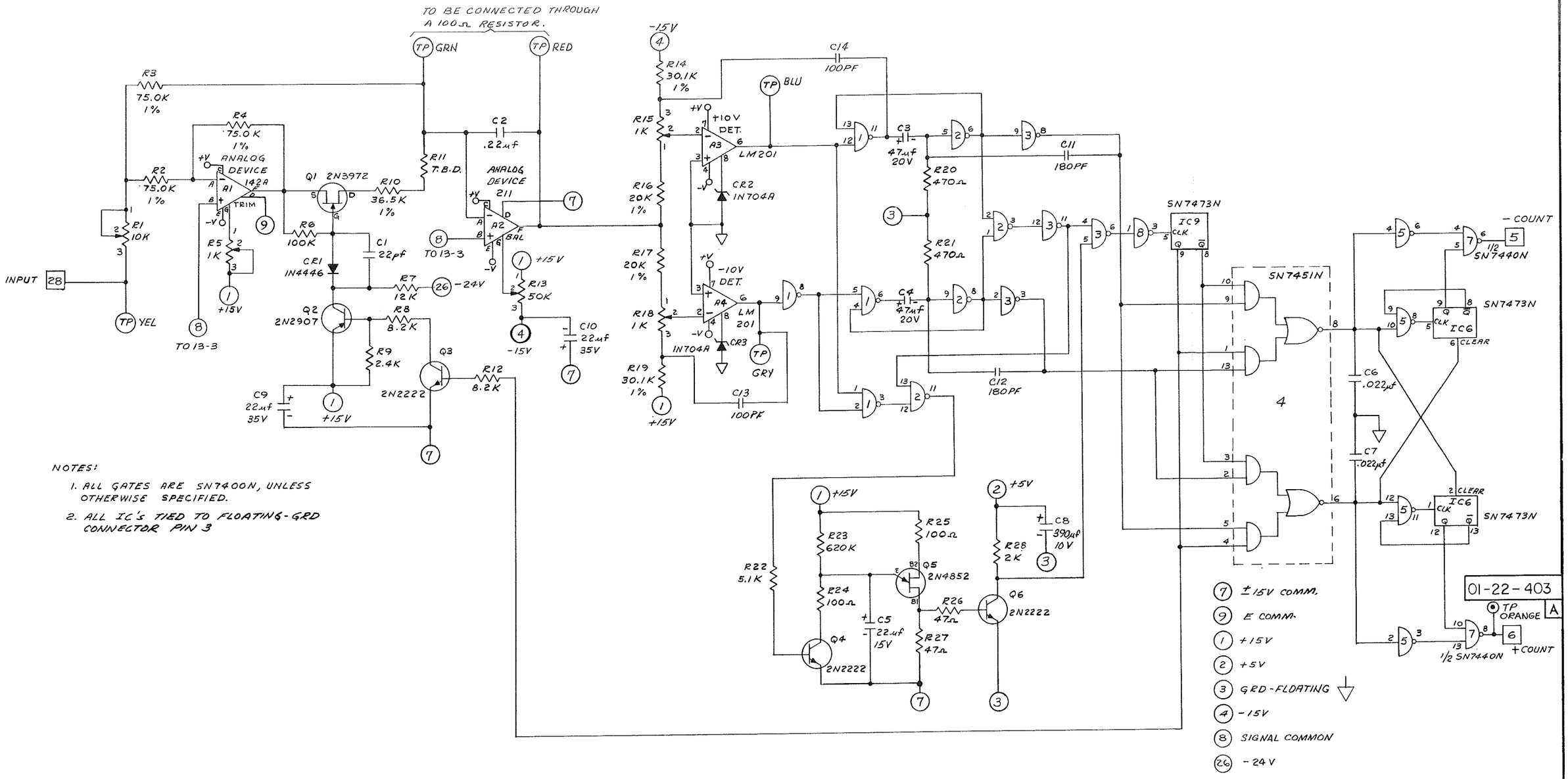
DRAWN BY	Al Elliott	7-16-68
CHECKED	W R Wolf	4-7-70
ENGINEER	M Lampson	9-17-69
APPROVED	[illegible]	11-17-70
APPROVED		

EMR-AEROSPACE SCIENCES DIVISION
ELECTRO-MECHANICAL RESEARCH, INC.
COLLEGE PARK, MARYLAND

WATT HOUR METER
AMPERE HOUR COUNTER P9 & P10
LOGIC DIAGRAM

CODE IDENT NO.	SIZE	
06141	D	01-22-303 A
SCALE ~		SHEET 1 OF 1

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED
A	REVISED AND UPDATED DWG	11/24/69	R.O.A.



NOTES:

1. ALL GATES ARE SN7400N, UNLESS OTHERWISE SPECIFIED.
2. ALL IC's TIED TO FLOATING-GRD CONNECTOR PIN 3

(7) ± 15V COMM.
(9) E COMM.
(1) +15V
(2) +5V
(3) GRD-FLOATING
(4) -15V
(8) SIGNAL COMMON
(26) -24V

01-22-403 A

REQD	PART NO.	ITEM	DESCRIPTION	SYM

LIST OF MATERIALS

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS DECIMALS ANGLES	DRAWN BY M. BEDROSIAN	DATE 8-15-65
	CHECKED W R Wirth	4-7-70
	ENGINEER M. Bedrosian	9-15-65
MATERIAL	APPROVED V. Bland	11-10-70
TREATMENT OR FINISH	APPROVED	

EMR-AEROSPACE SCIENCES DIVISION
ELECTRO-MECHANICAL RESEARCH, INC.
COLLEGE PARK, MARYLAND

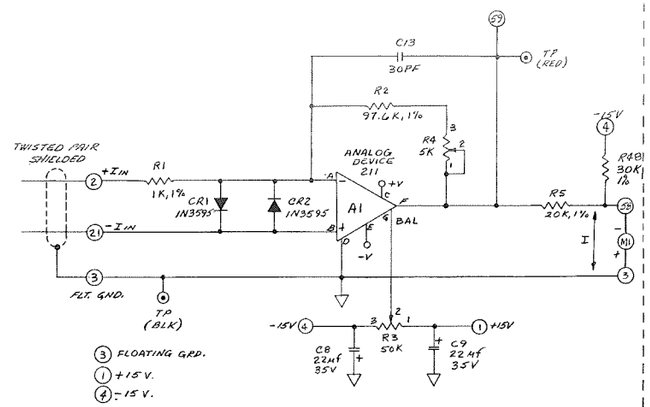
WATT HOUR METER CURRENT INTEGRATOR CARD P12 SCHEMATIC DIAGRAM

NEXT ASSY	USED ON

CODE IDENT NO.	SIZE	
06141	D	01-22-403 A

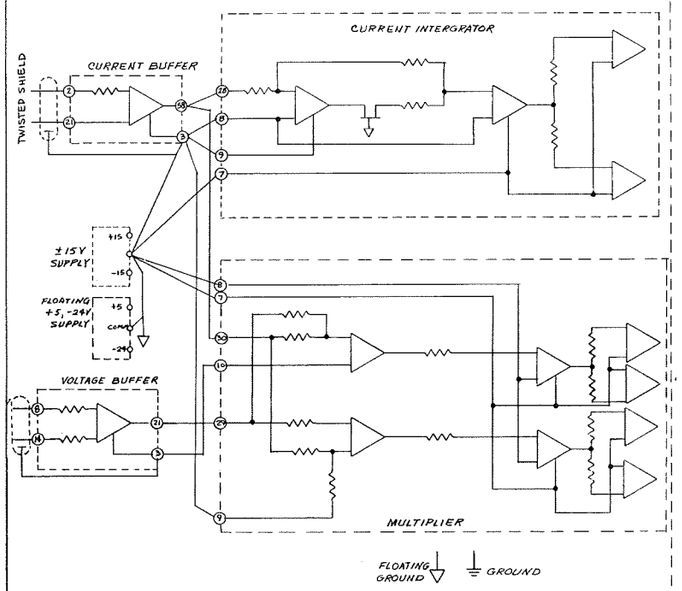
SCALE —— SHEET

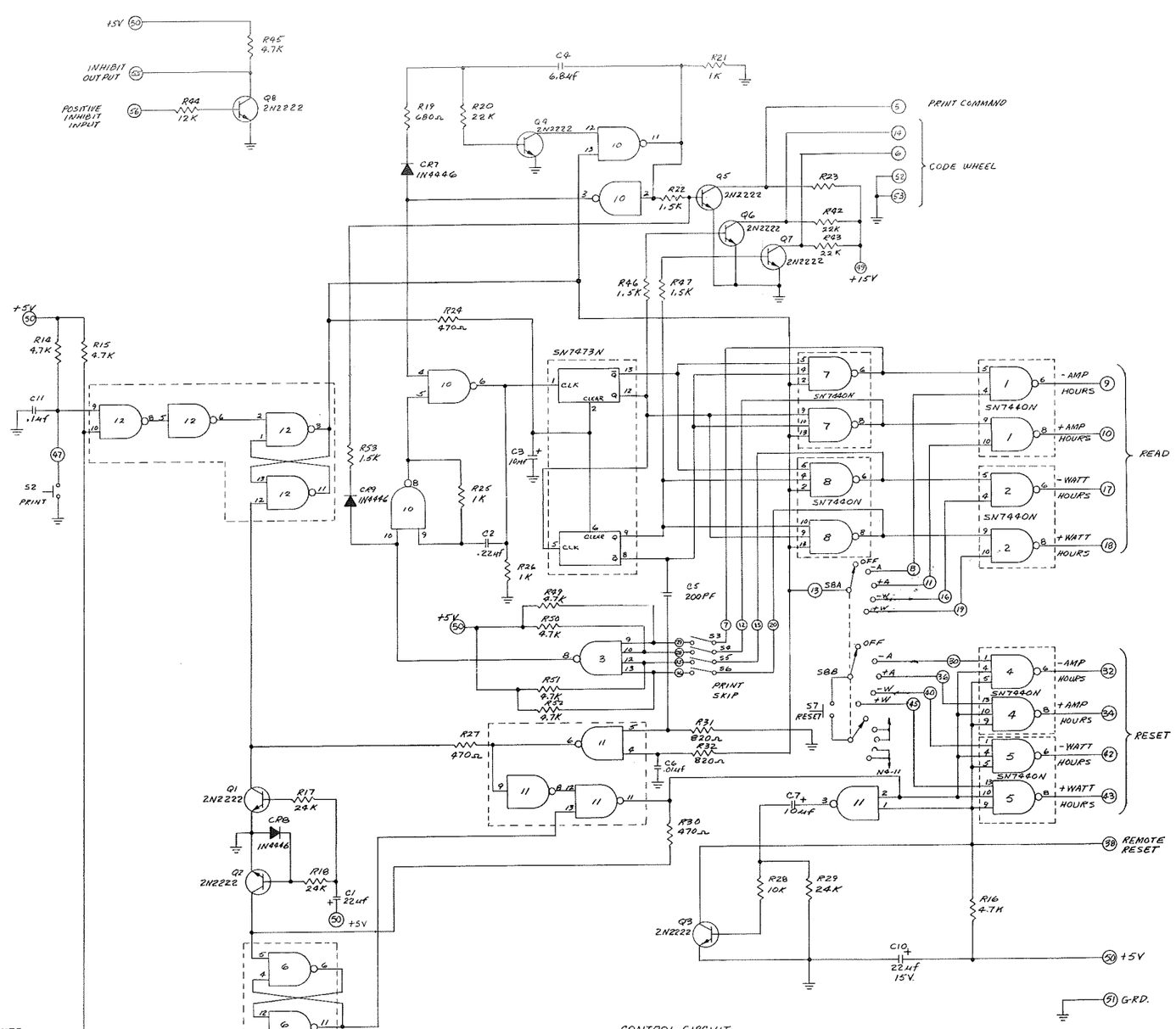
REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL
A	REVISED & REDRAWN	11-28-69	R.O.H.



CURRENT BUFFER

WHM GROUNDING PHILOSOPHY
(REFERENCE ONLY)





NOTES: UNLESS OTHERWISE SPECIFIED;
1. ALL GATES ARE SN7400N.

ITEM	PART NO.	DESCRIPTION

LIST OF MATERIALS

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON FRACTIONS ____ DECIMALS ____ ANGLES ____. MATERIAL ____. TREATMENT OR FINISH ____. NEXT ASSY 6341-9039 USED ON

DRAWN BY V. OSTROWSKI 11-28-69
CHECKED W. R. Wright 12-13-71
ENGINEER Ron Hayes 11-11-70
APPROVED [illegible] 11-12-71

Electro-Mechanical Research, Inc.
COLLEGE PARK, MARYLAND

SCHEMATIC DIAGRAM
WATT HOUR METER
CURRENT BUFFER & CONTROL CIR.
CARD P13

CODE IDENT NO. 06141 | SIZE E | 01-22-503 A

SCALE ____ SHEET 1 OF 1

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED
A	REVISED AND REDRAWN.	11-25-69	

NOTE: UNLESS OTHERWISE SPECIFIED;
1. ALL GATES ARE SN7400N.
2. FLOATING GRD. IS ELECTRICALLY ISOLATED FROM EARTH GND.

01-22-603 A

PULSE SUBTRACTOR

MULTIPLIER

(1) +15V
(2) +5V.
(3) FLOATING GRD.
(4) -15V.
(7) ±15V COMM
(8) SIGNAL COMM
(9) I COMM.
(10) E COMM.
(26) -24V.

REQD	PART NO.	ITEM	DESCRIPTION	SYM

LIST OF MATERIALS

NEXT ASSY	6341-9038	USED ON	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON FRACTIONS DECIMALS ANGLES
MATERIAL
TREATMENT OR FINISH

DRAWN BY	Ostrowski	DATE 11-25-69
CHECKED	R Wolfe	4-7-70
ENGINEER		11-13-70
APPROVED		11-17-70
APPROVED		

EMR-AEROSPACE SCIENCES DIVISION
ELECTRO-MECHANICAL RESEARCH, INC.
COLLEGE PARK, MARYLAND

SCHEMATIC DIAGRAM
WATT HOUR METER
MULTIPLIER & PULSE SUBTRACTOR
CARD PII

CODE IDENT NO.	SIZE	
06141	D	01-22-603 A

SCALE —— SHEET 1 OF 1

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED
A	REVISED	12-1-69	K.O.N.

J10-E
J10-F
± 15 V SUPPLY
+15 V
COM
-15 V
CR12 BRIDGE RECTIFIER
+ 115 V DC UNFILTERED
-
(2) MILLER TYPE 7825 LINE FILTER CHOKES
FL1
L1
F1
L1
FL2
F2
3A 250V
T1
R12 820Ω 1/2 W
CR1 IN2614
R1 820Ω, 1/2 W
CR8 UZ5217
R6 10K
R7 10K
R8 10K
R9 10K
R10 10K
R11 10K
+170 VDC
CR9 IN704A
+REF
C1 150μf 250 V
R13 62K 2W
CR2 UT236
R2 100Ω
C2 150μf 30 V
C3 150μf 30V
+15VDC
GND
CR10 IN4734
C4 500μf 10 V
C5 500μf 10V
CR3 IN1201
R3 20Ω
C10 5000μf 10V.
CR4 IN1201
Q1 2N4395 (HEAT SINK THERMALLOY 6401)
+15 VDC
CR5 UT236
Q2 2N4395
C11 2000μf 25V
R4 150Ω
CR6 UT236
CR11 IN4733A
C6 500μf 10V
CR13 IN914
C7 500μf 10V
C12 2000μf 25V
C13 2000μf 25V
CR7 UT236
C8 150μf 30V
R19 3.6K
C9 150μf 30V
R5 820Ω
FLOATING GRD
-24VDC FLOATING
TO VOLTAGE INPUT J2 & J4
+15V
-15V
+VIN
-VIN TBD
R5 10M, 1%
R33
R6 10M, 1%
CR3 IN3595
CR4 IN3595
CR5 IN3595
CR6 IN3595
C14 30PF
A2 143A
OUT
TRIM
R40 2K, 1%
R41 6K, 1%
R49 30.1K, 1%
R10
BLK
R7 0.1M, 1%
R34 TBD
R8 1M, 1%
R35 TBD
R9 10M, 1%
R36 TBD
R11 0.1M, 1%
R37 TBD
R12 1M, 1%
R38 TBD
R13 10M, 1%
R39 TBD
300V
100V
30V
10V
3V
S1A
S1B
S1C
S1D
S1E
1MA FS
M2
V
P14-17
P14-19
P14-26
P14-24
P14-28
P14-30
S9B
VOLTAGE BUFFER
IC 1
SN7400N
POWER SUPPLY

01-22-703
A

REQD	PART NO.	ITEM	DESCRIPTION	SYM

LIST OF MATERIALS

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS DECIMALS ANGLES	DRAWN BY E. LOGAN	DATE 8-23-68	EMR-AEROSPACE SCIENCES DIVISION ELECTRO-MECHANICAL RESEARCH, INC. COLLEGE PARK, MARYLAND
	CHECKED W R Work	4-7-70	WATT HOUR METER
	ENGINEER	9-1-68	VOLTAGE BUFFER & POWER SUPPLY CARD P14 SCHEMATIC
MATERIAL	APPROVED	11-17-70	
	APPROVED		
TREATMENT OR FINISH			CODE IDENT NO. 06141 / SIZE D / 01-22-703 A
NEXT ASSY 6341-9038	USED ON		SCALE ~ / SHEET

SECTION 8

WIRE LISTS

KEY TO WIRE LISTS

P	Plug
J	Jack
TB	Terminal Board
T	Transformer
N	Nixie Tube
S	Switch

WIRE LIST

WATT-HOUR METER

FROM	TO	FROM	TO
Card 1 Pin 1	P10-7	Card 1 Pin 48	N1-9
2	P9-7	49	P2-49
3	P8-6	50	P2-50
4	P7-6	51	P2-51
5	P10-8		
6	P9-8		
7	P8-9		
8	P7-9		
9	P10-10		
10	P9-10		
11	P8-10		
12	P7-10		
13	P10-11		
14	P9-11		
15	P8-11		
16	P7-11		
35	J5-36		
36	J5-12		
37	J5-11		
38	J5-37		
39	N1-3		
40	N1-4		
41	N1-7		
42	N1-14		
43	N1-2		
44	N1-12		
45	N1-10		
46	N1-13		
47	N1-5		

WIRE LIST

WATT-HOUR METER

FROM	TO	FROM	TO
Card 2 Pin 1	P10-13	Card 2 Pin 48	N2-9
2	P9-13	49	P3-49 (P1-49)
3	P8-13	50	P3-50 (P1-50)
4	P7-13	51	P3-51 (P1-51)
5	P10-14		
6	P9-14		
7	P8-14		
8	P7-14		
9	P10-16		
10	P9-16		
11	P8-16		
12	P7-16		
13	P10-17		
14	P9-17		
15	P8-17		
16	P7-17		
35	J5-34		
36	J5-10		
37	J5-9		
38	J5-35		
39	N2-3		
40	N2-4		
41	N2-7		
42	N2-14		
43	N2-2		
44	N2-12		
45	N2-10		
46	N2-13		
47	N2-5		

WIRE LIST

WATT-HOUR METER

FROM	TO	FROM	TO
Card 3 Pin 1	P10-19	Card 3 Pin 48	N3-9
2	P9-19	49	P4-49 (P2-49)
3	P8-19	50	P4-50 (P2-50)
4	P7-19	51	P4-51 (P2-51)
5	P10-20		
6	P9-20		
7	P8-20		
8	P7-20		
9	P10-23		
10	P9-23		
11	P8-23		
12	P7-23		
13	P10-24		
14	P9-24		
15	P8-24		
16	P7-24		
35	J5-32		
36	J5-8		
37	J5-7		
38	J5-33		
39	N3-3		
40	N3-4		
41	N3-7		
42	N3-14		
43	N3-2		
44	N3-12		
45	N3-10		
46	N3-13		
47	N3-5		

WIRE LIST

WATT-HOUR METER

FROM		TO
Card 4	Pin 1	P10-26
	2	P9-26
	3	P8-27
	4	P7-27
	5	P10-27
	6	P9-27
	7	P8-28
	8	P7-28
	9	P10-30
	10	P9-30
	11	P8-30
	12	P7-30
	13	P10-31
	14	P9-31
	15	P8-31
	16	P7-31
	35	J5-30
	36	J5-6
	37	J5-5
	38	J5-31
	39	N4-3
	40	N4-4
	41	N4-7
	42	N4-14
	43	N4-2
	44	N4-12
	45	N4-10
	46	N4-13
	47	N4-5

FROM		TO
Card 4	Pin 48	N4-9
	49	P5-49 (P3-49)
	50	P5-50 (P3-50)
	51	P5-51 (P3-51)

WIRE LIST

WATT-HOUR METER

FROM	TO	FROM	TO
Card 5 Pin 1	P10-33	Card 5 Pin 48	N5-9
2	P9-33	49	P6-49 (P4-49)
3	P8-34	50	P6-50 (P4-50)
4	P7-34	51	P6-51 (P4-51)
5	P10-34		
6	P9-34		
7	P8-35		
8	P7-35		
9	P10-36		
10	P9-36		
11	P8-38		
12	P7-38		
13	P10-37		
14	P9-37		
15	P8-39		
16	P7-39		
35	J5-28		
36	J5-4		
37	J5-3		
38	J5-29		
39	N5-3		
40	N5-4		
41	N5-7		
42	N5-14		
43	N5-2		
44	N5-12		
45	N5-10		
46	N5-13		
47	N5-5		

WIRE LIST

WATT-HOUR METER

FROM		TO
Card 6	Pin 1	P10-40
	2	P9-40
	3	P8-41
	4	P7-41
	5	P10-41
	6	P9-41
	7	P8-42
	8	P7-42
	9	P10-43
	10	P9-43
	11	P8-44
	12	P7-44
	13	P10-44
	14	P9-44
	15	P8-45
	16	P7-45
	35	J5-26
	36	J5-2
	37	J5-1
	38	J5-27
	39	N6-3
	40	N6-4
	41	N6-7
	42	N6-14
	43	N6-2
	44	N6-12
	45	N6-10
	46	N6-13
	47	N6-5

FROM		TO
Card 6	Pin 48	N6-9
	49	P13-49 (P5-49)
	50	P7-50 (P5-50)
	51	P7-51 (P5-51)

WIRE LIST

WATT-HOUR METER

FROM	TO	FROM	TO
Card 7 Pin 2	J10-C	Card 7 Pin 44	P6-12
3	J10-D	45	P6-16
4	P8-4	46	P8-46
5	P8-5	47	P8-47
6	P8-6	48	P11-51
8	P1-4	49	P8-49
9	P1-8	50	P6-50 P8-50
10	P1-12	51	P6-51 P8-51
11	P1-16		
12	P13-43		
13	P2-4		
14	P2-8		
16	P2-12		
17	P2-16		
19	P3-4		
20	P3-8		
22	P13-18		
23	P3-12		
24	P3-16		
27	P4-4		
28	P4-8		
30	P4-12		
31	P4-16		
34	P5-4		
35	P5-8		
38	P5-12		
39	P5-16		
41	P6-4		
42	P6-8		

WIRE LIST

WATT-HOUR METER

FROM	TO	FROM	TO
Card 8 Pin 2	J9-C	Card 8 Pin 41	P6-3
3	J9-D	42	P6-7
4	P7-4	44	P6-11
	P9-4	45	P6-15
5	P7-5	46	P7-46
	P14-23		P14-27
6	P7-6	47	P7-47
	P14-29		P14-25
8	P1-3	48	P11-50
9	P1-7	49	P7-49
10	P1-11		P9-2
11	P1-15	50	P7-50
12	P13-42		P9-50
13	P2-3	51	P7-51
14	P2-7		P9-51
16	P2-11		
17	P2-15		
19	P3-3		
20	P3-7		
22	P13-17		
23	P3-11		
24	P3-15		
27	P4-3		
28	P4-7		
30	P4-11		
31	P4-15		
34	P5-3		
35	P5-7		
38	P5-11		
39	P5-15		

WIRE LIST

WATT-HOUR METER

FROM	TO
Card 9 Pin 1	P12-6
2	P8-49
	P10-2
4	P8-4
	P10-4
7	P1-2
8	P1-6
10	P1-10
11	P1-14
12	P13-34
13	P2-2
14	P2-6
16	P2-10
17	P2-14
19	P3-2
20	P3-6
22	P13-10
23	P3-10
24	P3-14
26	P4-2
27	P4-6
30	P4-10
31	P4-14
33	P5-2
34	P5-6
36	P5-10
37	P5-14
40	P6-2
41	P6-6

FROM	TO
Card 9 Pin 43	P6-10
44	P6-14
45	S9-A-10A
46	S9-A-100A
47	J8-C
48	J8-D
50	P8-50
	P10-50
51	P8-51
	P10-51

WIRE LIST

WATT-HOUR METER

FROM	TO	FROM	TO
Card 10 Pin 1	P12-5	Card 10 Pin 43	P6-9
2	P9-2	44	P6-13
	P11-2	45	P9-45
4	P9-4	46	P9-46
	P13-55	47	J7-C
7	P1-1	48	J7-D
8	P1-5	50	P9-50
10	P1-9		P13-50
11	P1-13	51	P9-51
12	P13-32		P13-51
13	P2-1		
14	P2-5		
16	P2-9		
17	P2-13		
19	P3-1		
20	P3-5		
22	P13-9		
23	P3-9		
24	P3-13		
26	P4-1		
27	P4-5		
30	P4-9		
31	P4-13		
33	P5-1		
34	P5-5		
36	P5-9		
37	P5-13		
40	P6-1		
41	P6-5		

WIRE LIST

WATT-HOUR METER

FROM	TO	FROM	TO
Card 11 Pin 1	TB1-3, #22 wire	Card 12 Pin 1	TB1-3, #22 wire
2	P12-2, #18 wire	2	P11-2, #18 wire P14-40, #18 wire
3	P12-3, #18 wire	3	P11-3, #18 wire P14-2, #18 wire
4	TB1-1, #22 wire	4	TB1-1, #22 wire
26	P12-26	5	P10-1
29	P14-21	6	P9-1
30	P13-59	26	P11-26 P14-33
50	P8-48	28	P13-59
51	P7-48	7	TB1-3, #20 wire
7	TB1-2, #20 wire	8	P13-3, #26 wire
8	TB1-7	9	P13-3, #20 wire
9	P13-3		
10	P14-3		
32	R13 gray		
33	R13 purple		
34	R12 blue		
35	R12 green		
36	R36 yellow		
37	R36 white		
38	R35 brown		
39	R35 orange		

WIRE LIST

WATT-HOUR METER

FROM		TO
Card 13 Pin	1	TB1-3, #22 wire
	2	J1 & J3, twisted shielded pair
	3	P12-8, #26 wire P12-9, #22 wire P13-21, #26 wire TB1-2, #18 wire
	4	TB1-1, #22 wire
	5	J5-23
	6	J5-15
	7	S3
	8	S8
	9	P10-22
	10	P9-22
	11	S8
	12	S4
	13	S8
	14	J5-16
	15	S5
	16	S8
	17	P8-22
	18	P7-22
	19	S8
	20	S6
	21	J1 & J3, twisted shielded pair
	25	S5
	26	S6
	28	S4
	29	S3
	30	S8

FROM		TO
Card 13 Pin	32	P10-12
	34	P9-12
	36	S8
	38	J6-G
	40	S8
	42	P8-12
	43	P7-12
	45	S8
	46	J6-C
	47	J6-E
	49	P6-49 P14-48
	50	P10-50 P14-42
	51	P10-51 P14-50
	52	J5-40
	53	J5-41
	55	P10-4
	56	J5-22
	59	11-30

WIRE LIST

WATT-HOUR METER

FROM	TO
Card 14 Pin 1	TB1-3, #22 wire
2	P12-3, #18 wire TB1-2, #18 wire TB3-2, #18 wire
3	P13-3
4	TB1-1, #22 wire
5	M2 (Neg)
17	S1-D
19	S1-D
21	P11-29
23	P8-5
24	S1-E
25	P8-47
26	S1-D
27	P8-46
28	S1-E
29	P8-6
30	S1-E
31	T1-12
33	P12-26
34	T1-11
36	T1-9
38	Q2 Collector, #18 wire, C11
39	Q2 Base, #18 wire
40	Q2 Emitter, #18 wire, C12, C13
42	J5-24 (Q1 Emitter, #18 wire) P13-50

FROM	TO
Card 14 Pin 44	(Q1 Collector, #18 wire) (CR3, CR4 cathodes)
46	Q1 Barl
47	J5-25
48	P13-49
49	T1-3
50	P13-51, C1, R13 Gnd Lug
51	R12
52	C1, R13
54	N1-1
55	N2
56	N3-1
57	N4-1
58	N5-1
59	N6-1
6	S1-A Shielded
7	S1-A Shielded
8	J2 & J4 Twisted Shielded Pair
10	S1-A Shielded
12	S1-B Shielded
14	J2 & J4 Twisted Shielded Pair
16	S1-B Shielded
18	S1-B Shielded

WIRE LIST

WATT-HOUR METER

CONNECTOR	FROM		TO	FUNCTION
J1 (Current input, front)	Pin	+	P13-2	Twisted Shielded Pair
		-	P13-21	
J2 (Voltage input, front)		+	P14-8	Twisted Shielded Pair
		-	P14-14	
J3 (Current input, rear)		+	P13-2	Twisted Shielded Pair
		-	P13-21	
J4 (Voltage input, rear)		+	P14-8	Twisted Shielded Pair
		-	P14-14	
J5 (External printer)		1	P6-37	A Bit
		2	P6-36	B Bit
		3	P5-37	A Bit
		4	P5-36	B Bit
		5	P4-37	A Bit
		6	P4-36	B Bit
		7	P3-37	A Bit
		8	P3-36	B Bit
		9	P2-37	A Bit
		10	P2-36	B Bit
		11	P1-37	A Bit
		12	P1-36	B Bit
		15	P13-6	A Bit
		16	P13-14	B Bit
		22	P13-56	Pos. Inhibit
		23	P13-5	Pos. Print Command
		24	P14-42	Neg. Reference
		25	P14-47	Pos. Reference

WIRE LIST

WATT-HOUR METER

CONNECTOR	FROM	TO	FUNCTION
J5 (External printer)	Pin 26	P6-35	C Bit
	27	P6-38	D Bit
	28	P5-35	C Bit
	29	P5-38	D Bit
	30	P4-35	C Bit
	31	P4-38	D Bit
	32	P3-35	C Bit
	33	P3-38	D Bit
	34	P2-35	C Bit
	35	P2-38	D Bit
	36	P1-35	C Bit
	37	P1-38	D Bit
	40	P13-52	C Bit
	41	P13-53	D Bit
	50	Gnd Lug	Ground
NOTE: Digit number is same as card number; e.g., card P6 drives digit 6. P13 drives identification code digit.			
J6 (Remote Control)	A	Rectifier Bridge +	+115V DC Output 115V DC Return
	B	Rectifier Bridge -	+115V DC Output 115V DC Return
	C	P13-46	Print and Reset
	D	J6-F	Signal Return
	E	P13-47	Print
	F	J6-D, H	Signal Return
	G	P13-38	Reset
	H	J6-F Gnd Lug	Signal Return

WIRE LIST

WATT-HOUR METER

CONNECTOR	FROM	TO	FUNCTION
J7 (Minus Ampere-Hour Count Output)	Pin C	P10-47	Count output
	D	P10-48	Count output
	E	J8-E	115 VAC
	F	J8-F	115 VAC Return
J8 (Plus Ampere-Hour Count Output)	C	P9-47	Count output
	D	P9-48	Count output
	E	J7-E J9-E	115 VAC
	F	J7-F J9-F	115 VAC Return
J9 (Minus Watt-Hour Count Output)	C	P8-2	Count output
	D	P8-3	Count output
	E	J8-E J10-E	115 VAC
	F	J8-F J10-F	115 VAC Return
J10 (Plus Watt-Hour Count Output)	C	P7-2	Count output
	D	P7-3	Count output
	E	J9-E	115 VAC
		Front Panel AC	fused AC
	F	J9-F	115 VAC
		Front Panel AC	fused AC

WIRE LIST

WATT-HOUR METER

SWITCH		FROM	TO	FUNCTION
S9 (Current Range)	Pin	S9-A-10A	P9-45	
		S9-A-100A	P9-46	
		S9-B-10A	S1-D - Wiper	
		S9-B-100A	S1-E - Wiper	

NOTE: All switches and other chassis components not included in the Wire List are shown on the schematic diagrams.

SECTION 9

PARTS LISTS

PARTS LIST

P.C. Card No. 1 to 6 (6 Driver Cards)

ITEM	REQ'D	DESCRIPTION	SYMBOL
1	30	Contact, Lower Tier, #60-7001-04-13 Varicon (Elco)	
2	29	Contact, Upper Tier, #60-7001-05-13 Varicon (Elco)	
3	1	Capacitor, 22 μf, 15v, K22C15K, (Kemet)	C1
4	4	Resistor, 1.5K, 5%, 1/4 W	R1 thru R4
5	4	Resistor, 22K, 5%, 1/4 W	R5 thru R8
6	1	Integrated Ckt, SN7400N (TI)	IC 1
7	2	Integrated Ckt, SN7440N (TI)	IC 2, IC 3
8	1	Integrated Ckt, SN7441N (TI)	IC 4
9	4	Transistor 2N2222	Q1 thru Q4

PARTS LIST

P.C. Card No. 7 & 8 (2 Watt-Hour Counter Cards)

ITEM	REQ'D	DESCRIPTION	SYMBOL
1	30	Contact, Lower Tier, #60-7001-04-13 Varicon (Elco)	
2	29	Contact, Upper Tier, #60-7001-05-13 Varicon (Elco)	
3	12	Integrated Ckt, SN7400N (TI)	IC 1 to 6, 16, 18 to 22
4	1	Integrated Ckt, SN7440N (TI)	IC17
5	9	Integrated Ckt, SN7490N (TI)	IC 7 to 15
6	1	Transformer, H-48 (UTC)	T1
7	1	Relay, MRR-1A, 6V 288Ω, 41F4227 (Struthersdunn)	K1
8	1	Transistor, 2N2222 (Mot.)	Q1
9	1	Diode, UT236 (Unitrode)	CR1
10	1	Capacitor, 22μf, 15V, K22C15K, (Kemet) Dipped Silver Mica	C1
11	1	Capacitor, .001μf, CD19FD102J03 (CDE) Dipped Silver Mica	C2
12	1	Capacitor, 100 pf, CD15FD101J03 (CDE) Ceramic High K Monolythic	C3
13	1	Capacitor, .47μf, 25V 5C023474X0250B3 (Spraque)	C4
14	4	Resistor, 4.7K, 1/4 W, 5%	R1 thru R4
15	1	Resistor, 2K, 1/4 W, 5%	R11
16	1	Resistor, 24K, 1/4 W, 5%	R9
17	2	Resistor, 510Ω, 1/4 W, 5%	R8, R10
18	1	Resistor, 430Ω, 1/4 W, 5%	R7
19	2	Resistor, 2.7K, 1/4 W, 5%	R6, R13
20	2	Resistor, 2.2K, 1/4 W, 5%	R5, R14
21	1	Resistor, 10K, 1/4W, 5%	R12

ITEM	REQ'D	DESCRIPTION	SYMBOL
22	1	Capacitor, 47 µf, 10V CS13BF476K (KEMET)	C5
23	1	Capacitor, .02 µf, 500V	C6
24	1	Capacitor, 3300 pf 500V SD19FD332J03 (CDE) Dipped Silver Mica	C7
25	4	Capacitor, .01 µf, 100V (erie)	C8 thru C11
26	1	Resistor, 150 µf, 1/4W, 5%	R15
27	10	Jumper Wires, Insulated, AWG. #24	

PARTS LIST

P.C. Card No. 9 & 10 (2 Amp-Hour Counter Cards)

ITEM	REQ'D	DESCRIPTION	SYMBOL
1	30	Contact, Lower Tier, #60-7001-04-13 Varicon (Elco)	
2	29	Contact, Upper Tier, #60-7001-05-13 Varicon (Elco)	
3	11	Integrated Ckt, SN7400N (TI)	IC 1 to IC 6, IC 14 to IC 18
4	7	Integrated Ckt, SN7490N (TI)	IC 7 to IC 13
5	1	Transformer, H-48 (UTC)	T1
6	1	Relay, MRR-1A, 6V, 288Ω, 41F4227 (Struthersdunn)	K1
7	1	Transistor, 2N2222 (Mot.)	Q1
8	1	Diode, UT 236 (Unitrode)	CR1
9	1	Capacitor, 22μf, 15V, K22C15K (Kemet) Dipper Silver Mica	C1
10	1	Capacitor, .001μf, CD19FD102J03 (CDE) Dipped Silver Mica	C2
11	1	Capacitor, 100pf, CD15FD101J03 (CDE)	C4
12	1	Capacitor, .47μf, 25V, Ceramic High K Monolythic 5C023474X0250B3 (Spraque)	C3
13	2	Resistor, 4.7K, 1/4W, 5%	R1, R2
14	1	Resistor, 2K, 1/4W, 5%	R9
15	1	Resistor, 24K, 1/4W, 5%	R11
16	2	Resistor, 510Ω, 1/4W, 5%	R8, R10
17	1	Resistor, 430Ω, 1/4 W, 5%	R7
18	2	Resistor, 2.7K, 1/4W, 5%	R4, R5
19	2	Resistor, 2.2K, 1/4W, 5%	R3, R6
20	1	Resistor, 10K, 1/4W, 5%	R12
21	1	Resistor, 150, 1/4W, 5%	R13

ITEM	REQ'D	DESCRIPTION	SYMBOL
22	1	Capacitor, 47µf, 35V, CS13BF476K (KEMET)	C5
23	3	Capacitor, .02µf, 500V	C6, C7, C8
24	1	Jumper Wire, Insulated, AWG. #24	

PARTS LIST

P.C. Card No. 11 (Multiplier & Pulse Subtractor)

ITEM	REQ'D	DESCRIPTION	SYMBOL
1	30	Contact, Lower Tier, #60-7001-04-13 Varicon (Elco)	
2	29	Contact, Upper Tier, #60-7001-05-13 Varicon (Elco)	
3	3	Integrated Ckt, SN7400N (TI)	IC 1, IC 2, IC 3
4	2	Integrated Ckt, SN7440N (TI)	IC 4, IC 6
5	1	Integrated Ckt, SN7473N (TI)	IC 5
6	6	Operational Amplifier, LM201, Nat. Sem.)	A1, A3, A4, A5, A7, A8
7	2	Operational Amplifier, Model 149A (Analog Devices)	A2, A6
8	4	Transistor 2N3677 (Crystalonics)	Q2, Q3, Q5, Q6
9	2	Transistor, 2N2907 (Mot.)	Q1, Q4
10	4	Diode, 1N4446 (GE)	CR1, CR2, CR5, CR6
11	4	Diode, 1N704A (IR)	CR3, CR4, CR7, CR8
12	2	Capacitor, 30pf, DN10ED300J03 (Elmenco)	C1, C4
13	2	Capacitor, .01μf CYFM Glass (Corning Glassworks)	C2, C5
14	2	Capacitor, 22μf, 35V, K22C35K (Kemet)	C7, C8
15	1	Capacitor, 22μf, 15V, K22C15K (Kemet)	C10
16	1	Capacitor, .022μf, 25V 3C023223X0250A3, Ceramic High K Monolythic (Spraque)	C9
17	2	Capacitor, 47pf, CD15ED470J03 (CDE), Dipped Silver Mica	C3, C6

ITEM	REQ'D	DESCRIPTION	SYMBOL
18	6	Trim Potentionmeter, 1K, Helipot Helitrim, 77PR	R7, R15, R33 R38
19	2	Resistor, RN60D, Metal Film, 1/4, 1%, 10.0K, (Electra)	R2, R26
20	3	Resistor, RN60D, Metal Film, 1/4W, 1%, 5.11K, (Electra)	R5, R27, R28
21	2	Resistor, RN60D, Metal Film, 1/4W, 1%, 18.2K, (Electra)	R8, R34
22	2	Resistor, RN60D, Metal Film, 1/4W, 1%, 16.2K (Electra)	R13 R36
23	2	Resistor, RN60D, Metal Film, 1/4W, 1%, 8.06K, (Electra)	R46, R47
24	4	Resistor, RN60D, Metal Film, 1/4W, 1%, 20.0K, (Electra)	R17, R19, R39 R43
25	4	Resistor, RN60D, Metal Film, 1/4W, 1%, 30.1K, (Electra)	R16, R20, R39 R43
26	2	Resistor, RN60D, Metal Film, 1/4W, 1%, 3.0K, (Electra)	R4, R24
27	8	Resistor, TBD, 1/4W, 5%, Comp.	R1, R3, R23, R25
28	2	Resistor, 15K, 1/4W, 5%, Comp.	R9, R30
29	2	Resistor, 20K, 1/4W, 5%, Comp.	R10, R31
30	2	Resistor, 680 , 1/4W, 5%, Comp.	R11, R32
31	2	Resistor, 2.2K, 1/4W, 5%, Comp.	R22, R45
32	2	Resistor, 2.7K, 1/4W, 5%, Comp.	R21, R44
33	10	PC Mounting Test Points YEL(2), BRN(1), GRN(1), RED(1) BLU(1), WH(1), ORG(1), BLK(1)	
34	4	Resistor, Value to be determined	R12, R14, R35 R37

ITEM	REQ'D	DESCRIPTION	SYMBOL
35	4	Resistor, 510, 1/4W, 5%, Comp.	R48 thru R51
36	2	Resistor, 5.1meg, 1/4W, 5%, Comp.	R18, R41, R52, R53
37	*	Pot. 4 Section Ganged 2 Section 1K 2 Section 500	R54-A thru D
38	*	Resistor, 50 Ω, 1/4W, 1%	R55, R57
39	*	Resistor, 100 Ω, 1/4W, 1%	R56, R58
40	12	Jumper Wires, Insulated, AWG. #24	

* Mounted on Chassis

PARTS LIST

P. C. Card No. 12 (Current Time Integrator)

ITEM	REQ'D	DESCRIPTION	SYMBOL
1	30	Contact Lower Tier, #60-7001-04-13 Varicon (Elco)	
2	29	Contact Upper Tier, #60-7001-05-13 Varicon (Elco)	
3	5	Integrated Ckt, SN7400N (TI)	IC 1, IC 2, IC 3, IC 5, IC 8
4	2	Integrated Ckt, SN7473N (TI)	IC 6, IC 9
5	1	Integrated Ckt, SN7451N (TI)	IC 4
6	1	Integrated Ckt, SN7440N (TI)	IC 7
7	2	Operational Amplifier, LM201, (Nat. Sem.)	A3, A4
8	1	Operational Amplifier, Model 142A, (Analog Devices)	A1
9	1	Operational Amplifier, Model 211 (Analog Devices)	A2
10	3	Transistor, 2N2222 (Mot.)	Q3, Q4, Q6
11	1	Transistor, 2N2907 (Mot.)	Q2
12	1	Transistor, 2N3972 Silconix	Q1
13	1	Transistor, 2N4852 (Mot.)	Q5
14	1	Diode, 1N4446 (GE)	CR1
15	2	Diode, 1N704A (IR)	CR2, CR3,
16	1	Capacitor, 22pf, Dipped Silver Mica, CD15CD220J03 (CDE)	C1
17	1	Capacitor, .22μf, MFP, MYLAR, 1 P22, (CDE)	C2
18	2	Capacitor, 47μf, 20V, K47J02KS (Kemet)	C3, C4
19	2	Capacitor, 22 μf, 35V, K22C35K, (Kemet)	C9, C10

P.C. Card No. 12 (Current Time Integrator)

ITEM	REQ'D	DESCRIPTION	SYMBOL
20	1	Capacitor, 22μf, 15V, K22C15K, (Kemet)	C5
21	2	Capacitor, .022μf, 25V, Ceramic Monolythic, 3C023223KO250A3, (Spraque)	C6, C7
22	4	Trim Potentiometer, 1K, Helipot Helitrim, 77PR	R1, R5, R15, R18
23	1	Trim Potentiometer, 50K, Helipot Helitrim, 77PR	R13
24	3	Resistor, RN60D, Metal Film, 1/4 W, 1%, 75.0K (Electra)	R2, R3, R4
25	1	Resistor, RN60D, Metal Film, 1/4 W, 1%, 36.5K, (Electra)	R10
26	2	Resistor, RN60D, Metal Film, 1/4 W, 1%, 20.0K (Electra)	R16, R17
27	2	Resistor, RN60D, Metal Film, 1/4 W, 1%, 30.1K (Electra)	R14, R19
28	1	Resistor, TBD, 1/4 W, 5%, Comp.	R11
29	1	Resistor, 100K, 1/4 W, 5%, Comp.	R6
30	1	Resistor, 12K, 1/4 W, 5%, Comp.	R7
31	2	Resistor, 8.2K, 1/4 W, 5%, Comp.	R8, R12
32	1	Resistor, 2.4K, 1/4 W, 5%, Comp.	R9
33	2	Resistor, 470Ω, 1/4 W, 5%, Comp.	R20, R21
34	1	Resistor, 5.1K, 1/4 W, 5%, Comp.	R22
35	1	Resistor, 620K, 1/4 W, 5%, Comp.	R23
36	2	Resistor, 100Ω, 1/4 W, 5%, Comp.	R24, R25
37	2	Resistor, 47Ω, 1/4 W, 5%, Comp.	R26, R27
38	1	Resistor, 2K, 1/4 W, 5%, Comp.	R28
39	6	PC Mounting Test Points, Yel(1), Grn(1), Red(1), Blu(1), Gry(1), Org(1)	

ITEM	REQ'D	DESCRIPTION	SYMBOL
40	2	Capacitor, 100pf, 500V, CD15Fd101J03 (CDE) Dipped Silver Mica	C13, C14
41	2	Capacitor, 180pf, 500V, CD7CD181G03 (CDE) Dipped Silver Mica	C11, C12
42	1	Capacitor, 390 µf, 10V	C8
43	8	Jumper Wires, Insulated, AWG. #24	

PARTS LIST

P.C. Card No. 13 (Control Circuit & Current Buffer)

ITEM	REQ'D	DESCRIPTION	SYMBOL
1	30	Contact, Lower Tier, #60-7001-04-13 Varicon (Elco)	
2	29	Contact, Upper Tier, #60-7001-05-13 Varicon (Elco)	
3	4	Integrated Ckt, SN7400N (TI)	IC6, IC10, IC11, IC12
4	7	Integrated Ckt, SN7440N (TI)	IC 1, IC2, IC3, IC4, IC5, IC7 IC8
5	1	Integrated Ckt, SN7473N (TI)	IC9
6	1	Operational Amplifier, Model 211 (Analog Devices)	A1
7	8	Transistor, 2N2222 (Mot.)	Q1 thru Q8
8	3	Diode, 1N4446 (GE)	CR7, CR8, CR9
9	2	Diode, 1N3595 (Fairchild)	CR1, CR2
10	2	Capacitor, 22μf, 15V, K22C15K, (Kemet)	C1, C10
11	2	Capacitor, 200pf, Dipped Silver Mica, CD15FD201J03 (CDE)	C2, C5
12	2	Capacitor, 10μf, 20V, K10J20KS (Kemet)	C3, C7
13	1	Capacitor, 6.8μf, 35V, K6R8J35KS (Kemet)	C4
14	1	Capacitor, .01μf, 25V, Ceramic High K Monolythic, 3C023103X0250A3 (Spraque)	C6
15	2	Capacitor, 22μf, 35V, K22C35K (Kemet)	C8, C9
16	1	Trim Potentiometer, 5K, Helipot Helitrim, 77PR	R4
17	1	Trim Potentiometer, 50K, Helipot Helitrim, 77PR	R3

P.C. Card No. 13 (Control Circuit & Current Buffer)

ITEM	REQ'D	DESCRIPTION	SYMBOL
18	1	Resistor, RN60D, Metal Film, 1/4 W, 1%, 1.00K (Electra)	R1
19	1	Resistor, RN60D, Metal Film, 1/4 W, 1%, 97.6K (Electra)	R2
20	1	Resistor, TBD, 1/4 W, 5%, Comp.	R5
21	1	Resistor, TBD, 1/4 W, 5%, Comp.	R48
22	8	Resistor, 4.7K, 1/4 W, 5%, Comp.	R14, R15, R16, R45 R49, R50, R51, R52
23	1	Resistor, 12K, 1/4W, 5%, Comp.	R44
24	3	Resistor, 24K, 1/4 W, 5%, Comp.	R17, R18, R29
25	1	Resistor, 680Ω, 1/4 W, 5%, Comp.	R19
26	3	Resistor, 22K, 1/4 W, 5%, Comp.	R20, R42, R43
27	3	Resistor, 1K, 1/4 W, 5%, Comp.	R21, R25, R26
28	4	Resistor, 1.5K, 1/4 W, 5%, Comp.	R22, R46, R47, R53
29	1	Resistor, 2.4K, 1/4 W, 5%, Comp.	R23
30	3	Resistor, 470Ω, 1/4 W, 5%, Comp.	R24, R27, R30
31	1	Resistor, 10K, 1/4 W, 5%, Comp.	R28
32	2	Resistor, 820Ω, 1/4 W, 5%, Comp.	R31, R32
33	2	PC Mounting Test Point, (one Red, one Black)	
34	1	Capacitor, 30pf. 500V, CD15ED300J03 (CDE), Dipped Silver Mica	C13
35	2	Capacitor, .1μf, 500V erie	C11, C12

PARTS LIST

P. C. Card No. 14 (Power Supply & Voltage Buffer)

ITEM	REQ'D	DESCRIPTION	SYMBOL
1	30	Contact, Lower Tier, #60-7001-04-13 Varicon (Elco)	
2	29	Contact, Upper Tier, #60-7001-04-13 Varicon (Elco)	
		POWER SUPPLY	
3	1	Integrated Ckt, SN7400N (TI)	IC1
4	*	Transistor, 2N4395 (RCA)	Q1, Q2
5	4	Diode, UT236 (Unitrode)	CR2, CR5, CR6 CR7
6	1	Diode, 1N2614 (GE)	CR1
7	1	Diode, U25217 (Unitrode)	CR8
8	1	Diode, 1N4733A (Mot.)	CR11
9	1	Diode, W704A (IR)	CR9
10	1	Diode, 1N4734 (Mot.)	CR10
11	4	Capacitor, 150μf, 30V, WF 150-30C3M (Tansitor)	C2, C3, C8, C9
12	4	Capacitor, 500μf, 10V, 390507G010Ej4 (Spraque)	C4, C5, C6, C7
13	1	Resistor, 820Ω, 1/2W, 5%Comp.	R1
14	1	Resistor, 100Ω, 1/4W, 5%Comp.	R2
15	1	Resistor, 20Ω, 1/4W, 5%Comp.	R3
16	1	Resistor, 150Ω, 1/4W, 5%Comp.	R4
17	1	Resistor, 820Ω, 1/4W, 5%Comp.	R5
18	6	Resistor, 10KΩ, 1/4W, 5%Comp.	R6 thru R11
19	1	Heat Sink, 6401, Thermalloy	
20	*	Diode, 1N1201	CR3, CR4
21	*	Resistor, 820Ω, 1/2W, 5%Comp.	R12
22	*	Resistor, 62K, 2W, 5% Comp.	R13
23	1	Diode, 1N914	CR13

* Mounted on Chassis

P. C. Card No. 14 (Power Supply & Voltage Buffer) Page 2

ITEM	REQ'D	DESCRIPTION	SYMBOL
24	1	Resistor, 3.6K, 1/4W, 5%, Comp.	R14
25	*	Capacitor, 5000 f, 10V	C10
26	*	Capacitor, 2000 f, 25V	C11, C12, C13
27	2	Jumper Wires, Insulated, AWG. #24	

* Mounted on Chassis

ITEM	REQ'D	DESCRIPTION	SYMBOL
		VOLTAGE BUFFER	
1	1	Operational Amplifier, Model 143A (Analog Devices)	A2
2	4	Diode, 1N3595 (Fairchild)	CR3 to CR6
3	1	Trimpot, 2K, 77PR2K (Beckman)	R10
4	2	Resistor, 100K, RN60D, Metal Film, 1/4 W, 1%	R7, R11
5	2	Resistor, 1M, RN60D, Metal Film, 1/4 W, 1%	R8, R12
6	1	Resistor, 30.1K, RN60D, Metal Film, 1/4 W, 1%	R49
7	4	Resistor, 10M, RN60D, Metal Film, 1W, 1%	R5, R6, R9, R13
8	5	Resistor, TBD, Carbon Comp., 1/4 W, 5%	R33 to R39
9	1	Resistor, 2K, RN60D, Metal Film, 1/4 W, 1%	R40
10	1	Resistor, 6.04K, RN60D, Metal Film, 1/4 W, 1%	R41
11	2	PC Mounting Test Points RED (1), BLK (1)	
12	1	Capacitor, 30Pf, 500V, CD15ED300J03 (CDE), Dipped Silver Mica	C14

PARTS LIST

Chassis

ITEM	REQ'D	DESCRIPTION	SYMBOL
1	1	Line Cord, 17236-SV (Belden)	
2	2	Line Filter Choke, 7825 (Miller)	FL1, FL2
3	1	Fuseholder, 342001 (Littlefuse)	F2
4	1	Switch, Fuse, Pilot Light, FCB-F (Rowen)	S10, F1, L1
5	1	Transformer, BX5420 (Balt. Transformer Co.)	T1
6	1	Power Supply, NPS-300 (Philbrick)	
7	1	Bridge Rectifier (Semtech)	CR12-(14)
8	1	Capacitor, 150μf, 250V, TVL1540 (Spraque)	C1-(14)
9	1	Switch, Rotary, PA2022 (Centralab)	S1
10	2	Switch, Push Button, 3391-GL, (Arrow-Hart)	S2, S7
11	4	Switch, Toggle, MST105D (Alcoswitch)	S3, S4, S5, S6
12	1	Switch, Rotary, PA2011 (Centralab)	S8
13	1	Switch, Rotary, PA2002 (Centralab)	S9
14	2	Meter, Type 1622, 0-1 DCMA (Simpson)	M1, M2
15	14	Binding Post, 224BB (H.H.Smith)	P1 to P14
16	3	Connector, 00-7015-059-218-001 (Elco)	J1 to J3
17	1	Connector, MS3102A10 SL-4P	J4
18	1	Connector, 57-40500 (Amphenol)	J5
19	1	Connector, MS3102A 20-27	J6
20	4	Connector, MS3102A-14S-6S	J7 to J10
21	1	Bezel Ass'y., SFB34-S4-6 w/SK182 Socket, 6 Wide	

ITEM	REQ'D	DESCRIPTION	SYMBOL
22	5	Nixie Tubes, B5440, (Burroughs)	N1, N2, N3, N5, N6
23	1	Nixie Tube, B5441 (Burroughs)	N4
24	3	Knob, DS70-3-2 (Raytheon)	
25	2	Transistor, 2N4395 (RCA)	Q1, Q2-(14)
26	2	Diode, 1N1201	CR3, CR4-(14)
27	1	Resistor, 820Ω, 1/2W, 5%, Comp.	R12-(14)
28	1	Resistor, 62K, 2W, 5%, Comp.	R13-(14)
29	1	Capacitor, 5000μf, 10V	C10-(14)
30	3	Capacitor, 2000μf, 25V	C11, C12, C13-(14)
31	1	Pot. 4Section Ganged, 2 Section 1K, 2Section 500Ω	R54-A, B, C, D (11)
32	2	Resistor, 50Ω, 1/4W, 1%	R55, R57
33	2	Resistor, 100Ω, 1/4W, 1%	R56, R58
34	1	Resistor, 100K, 1%, Metal Film, RN55C	

ITEM	REQ'D	DESCRIPTION	SYMBOL
		ACCESSORIES	
1	1	Receptacle, 59 Contact 00-7015-217-001, Varicon (ECCO)	
2	1	Contact Lower Tier, 30Contacts 02-030-135-5200, Varicon (ECCO)	
3	1	Contact Upper Tier, 29 Contacts 02-029-137-5200, Varicon (ECCO)	

SECTION 10

TIMING TEST SHEETS

WATT HOUR METER TIMING TESTS

The following tests check the accuracy, drift, and operation of the Watt-Hour Meter. The technique used to obtain an accurate time interval for a measurement is to apply V_{IN} and then apply I_{IN} simultaneously with starting the clock or stopwatch. Then I_{IN} is disconnected precisely at the end of the measurement period and the readings on the counters are recorded. Since the counters operate only when I_{IN} is connected, the measurement period can be fairly controlled by this means. The resulting measurements are more accurate than those obtained by trying to read the Nixie Display while it is counting.

V_{IN} (volts)	I_{IN} (mv)	Time (min)	Volts Range	Amps Range	Nominal Amp-Hr	Actual Amp-Hrs	% Error	Nominal Watt-Hr	Actual Watt-Hr	% Error
+3.000	+100.0	6	3v	100A	+10.000			+30.00	30.16	.53%
+3.000	-100.0	3	3v	100A	- 5.000	-4.996	.12%	- 15.00	-15.03	.2%
-3.000	-100.0	3	3v	100A	- 5.000	-4.998	.1%	+ 15.00	14.95	.33%
+.3000	+ 10.0	6	3v	100A	+ 1.000	1.000	0	+ .30	.31	3.3%
+30.00	+1.000	6	30v	100A	+ .100	.100	0	+ 3.00		
- 10.00	+100.0	6	30v	10A	+ 1.000	1.002	.2%	- 10.00	10.08	.8%
Short	Short	6	300v	100A	± zero			± zero		

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+3.000	+100.0	6	3v	100A	+10.000			+30.00		
+3.000	-100.0	3	3v	100A	- 5.000			- 15.00		
-3.000	-100.0	3	3v	100A	- 5.000			+ 15.00		
+.3000	+ 10.0	6	3v	100A	+ 1.000			+ .30		
+30.00	+1.000	6	30v	100A	+ .100			+ 3.00		
-10.00	+100.0	6	30v	10A	+ 1.000			- 10.00		
Short	Short	6	300v	100A	± zero			± zero		

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+3.000	+100.0	6	3v	100A	+10.000	_____	_____	+30.00	_____	_____
+3.000	-100.0	3	3v	100A	- 5.000	_____	_____	- 15.00	_____	_____
-3.000	-100.0	3	3v	100A	- 5.000	_____	_____	+ 15.00	_____	_____
+.3000	+ 10.0	6	3v	100A	+ 1.000	_____	_____	+ .30	_____	_____
+30.00	+1.000	6	30v	100A	+ .100	_____	_____	+ 3.00	_____	_____
-10.00	+100.0	6	30v	10A	+ 1.000	_____	_____	- 10.00	_____	_____
Short	Short	6	300v	100A	± zero	_____	_____	± zero	_____	_____